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THE UNIVERSITY OF ALBERTA

HIGH TECHNOLOGY DEVELOPMENT IN ALBERTA

by

CRAIG V. CHRISTY

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF ARTS

GEOGRAPHY

EDMONTON, ALBERTA

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Supervisor

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....

....

Date. April 22 / 1986.

Abstract

In recent years high technology has moved into the forefront in regional economic development strategies throughout North America and Europe. The attraction of high technology more recently spilled over into the province of Alberta, a peripheral region in Western Canada which is seeking to diversify its resource based economy. In this regard the provincial government released its industrial strategy (White Paper) which emphasized high technology development in July 1984, and the Department of Technology, Research and Telecommunications was recently established in February, 1986.

The overall objective of this thesis was to provide a greater understanding of high technology development in Alberta by assessing the province's existing high technology base. The study was based on 116 questionnaire responses received from high technology firms in the province, most of which were located in the metropolitan cities of Edmonton and Calgary. Based on a literature review of high technology development elsewhere, a series of 29 research hypotheses were formulated and tested under the following categories: Categorization of High Technology Firms In Alberta, Commercial Performance of High Technology Firms, Location Factors and Government Support Programs.

The data revealed that the high technology sector in Alberta is generally immature. Most firms are small independently-owned Alberta companies which are privately held, and were established more than six years ago. In addition, they are manufacturing products predominantly in the electronics and communications, and computer areas, but a large proportion of them sell specialized services.

Analysis of financial trends found that Alberta's high technology firms are surviving and growing. Corporate executives and management further exhibited optimism about the future potential for their firms. Most firms were found to conduct full-time internal R&D programs, which emphasized new products/process development. In addition to product diversification, geographic diversification of markets was found to be important among high technology firms.

Research parks were unimportant influences on location with cost being cited as the major reason. "Overall Business Climate", "Founding Entrepreneur Lived There", "Access to Markets", "Labour Skills and Availability", "Political Stability" and "Provincial Tax Climate" were cited as the most important locational influences. The metropolitan locations of Edmonton and Calgary were clearly preferred over regional cities and small towns because of the availability of services.

Government programs were found to be unimportant to high technology firms with the exception of R&D initiatives and marketing. For high technology firms to grow and prosper in Alberta, most firms felt the provincial government should provide a stronger commitment to high technology, in addition to greater financial support for R&D.

Overall, the thesis research confirmed the existence of indigenous high technology development in a number of promising areas other than the oil and gas industry.

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I. Introduction

The province of Alberta possesses a relatively simple economic structure due to its reliance on the exploitation of raw materials. Economic growth has been historically determined by the expansion of the resource sector, or by growth of activities linked with it. Petroleum, natural gas and agricultural products are the major commodities which compose this resource sector. In 1984, the economic value of production generated by these groups totalled approximately $29 billion, of which 83% was derived from petroleum and natural gas sales.[1]

Large oil reserves were first discovered near Leduc in 1947, providing the stimulus for substantial economic growth during the immediate post World War II period. However, it was the dramatic price increases initiated by the Organization of Petroleum Exporting Countries (OPEC) since 1973 that contributed to rapid economic growth and prosperity in recent years.

Wright (1975) (in Barr and Fairbairn) discussed the advantages petroleum provided to Alberta's economy, and the changes it initiated in the province as a whole:

> ".... petroleum has been important to Alberta in providing large sums to the provincial treasury, in hastening urbanization and population expansion, in generation of a market which could be efficiently serviced by many seemingly related industries, and in permitting diversification for an economy which might otherwise have been rather unstable."[2]

The economic diversification alluded to by Wright generally coincides with the Conservative government's industrialization strategy of the 1970's. This strategy appears to parallel Rostow's theory which claims that regional economic development occurs in a sequence of stages evolving from a subsistence economy through the exploitation of resources to the early and advanced stages of industrialization.[3] However, the provincial government generally discounted the effects of external influences on economic growth, believing that by strengthening its control over the economy, Alberta could be protected from outside political and economic forces. This control would further enhance Alberta's bargaining position during federal-provincial pricing negotiations for the province's petroleum and agricultural resources. Alberta's politicians and business leaders, among others, have traditionally viewed these pricing agreements as being equitable for all of the provinces, except Alberta. They have also viewed

Alberta as an exploited dependent of Central Canada and that this condition had to change.

Changing the economic structure of Alberta is a formidable task. Due to a combination of locational, historical and economic factors, Alberta has always remained a periphery to central industrial Canada. The province lacks mature secondary industries which is reflected by a manufacturing sector dependent on the industrial core of Canada for 75-92% of its manufacturing inputs.[4] This reliance on production based outside the province, combined with its resource-based economy, are formidable facts to overcome by those interest groups which believe that economic change can only be accomplished by transforming the province from a periphery to an industrial core where wealth and power are located. Nevertheless, it is generally agreed that economic diversification requires the development of secondary industries in order to stabilize Alberta's economic structure and ensure economic growth. Former Premier Peter Loughheed cited the necessity of fostering "natural industries"[5] such as petrochemicals and agricultural food processing, thereby ensuring an economic transition from primary extractive industries to the processing of raw materials and manufacturing. An industrialized economy would be created and the employment opportunities for Albertans would be improved.[6]

The development of petrochemicals and agricultural processing represents a logical extension of the province's strength in energy resources and agriculture, and perhaps may be an effective long-term solution for the successful diversification of the Alberta economy. However, it has also been argued that if the government did not manage growth and direct the economy in this desired path, the province could ultimately become even more dependent on its natural resources. Some have even argued that petrochemicals and agricultural food processing did not constitute industrial diversification at all.[7]

In 1976, the Conservative government established the Heritage Savings Trust Fund, which derives its revenues from a percentage of oil and gas production sales and provincial royalties. A primary purpose of the fund is to provide capital for diversifying the economy before depleting oil and gas reserves are exhausted. Until recent years, industrial investment from the fund focused on those development industries directly related to the energy sector and did very little to encourage growth in other areas.[8]

As Alberta entered the 1980's, industrial diversification continued to be regarded as a major issue of economic development strategy. However, the economic recession which began in 1981 and the abrupt down-turn of world oil and natural gas prices inevitably forced the province to examine alternative means that would potentially broaden the province's economic base, reduce the dependency on oil and gas production, ensure economic growth, and add stability to the economy.

> "In the case of Alberta, industrial diversification is best defined as broadening and changing the composition of the industrial structure so there is less dependence on a few industries which are characterized by short-run price and income stability."[9]

While "broadening and changing the composition of the industrial structure" has only recently been addressed by a formally published government White Paper[10] designed to steer a course for Alberta's economic future, it is apparent that diversification requires the identification of industries that are capable of sustained growth and competitiveness.

It is becoming more and more evident throughout the world that above average growth and competitiveness are being achieved by the emerging high technology sector. High technology industries have exhibited about twice the increase in productivity, three times the growth rate, nine times the employment growth, and one-sixth the price increase that have characterized low technology industries.[11] World demand for high technology goods has been increasing at a rapid rate leading some economists to conclude that the 1980's and 1990's will belong to those countries that develop and extend their capability in high technology areas.[12] It is for these reasons that policy-makers are now seriously examining high technology industries to determine the potential for establishing them in Alberta. Indeed, the Alberta Department of Technology, Research and Telecommunications was recently established in February, 1986.

Analysis of the performance of high technology industries, factors contributing to their success, and locational patterns have important implications for regional economic development and planning. These areas of research are of critical importance at this time because provincial and local governments have traditionally viewed the establishment of high technology research and development parks as the necessary impetus for creating high technology industrial growth. Research parks have been introduced in Edmonton and Calgary, as well as several other locations across Canada, but for the most part remain in embryonic stages. The most important unanswered questions which must be addressed are: Can high technology industries be successfully introduced in the province of Alberta, thereby contributing to the economic diversification objective of the province? Do the research parks already introduced provide the necessary means for encouraging the establishment and growth of a high technology sector?

Study Objectives

The major objectives of this thesis are summarized as follows:

i. to assess the potential for establishing high technology industries in the province of Alberta by discussing and analysing the influence on locational decisions of firms elsewhere

ii. to analyse the factors which contribute to the growth and success of high technology firms

iii. to provide a historical review of the development of research parks to determine what factors have contributed to the success and failure of prominent parks in North America

iv. to provide a greater understanding of high technology development in Alberta by assessing the province's existing high technology base

v. to provide tentative conclusions about Alberta's location and economic advantages for establishing high technology industries, and provide preliminary recommendations for future direction

Endnotes: Chapter I: Introduction

1. Value of production from petroleum and natural gas sales totaled $24.6 billion. This total includes sales from crude petroleum, natural gas, and natural gas by-products. All figures are quoted from: Alberta Bureau of Statistics, Alberta Statistical Review, Fourth Quarter, 1985, p. 79, 107.

2. B.M. Barr and K.J. Fairbairn, "The Importance of Manufacturing Linkages to Urban Places in a Sparsely Populated, Resource Extractive Regional Economy". From the proceedings of the International Geographical Union Regional Conference and Eighth New Zealand Geographical conference: Auckland, New Zealand. New Zealand Geographic Society Conference Series No. 8, 1975, p. 21.

   A.S. Matthews, A Comparison of the Forces of Agglomeration Within Calgary's Industrial Parks, University of Calgary M.A. Thesis (unpublished), Department of Geography, 1979, p. 38.

3. See W.W. Rostow, "The Stages of economic Growth", Economic History Review, Vol. 12, No. 1 Second Series, 1959, pp. 1-16.

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5. Larry Pratt. "The State and Province Building: Alberta's Development Strategy", The Canadian State: Political Economy and Political Power, Leo Panitch (ed.), Toronto: University of Toronto Press, 1977, pp. 133-162.

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7. Alberta Department of Economic Development, Industrial Diversification in Alberta, (unpublished), September 1982, p. 2.

   Report on business, "Industrial Base Urged for Alberta", The Globe and Mail, (Toronto). Thursday, May 3, 1984, p. B23.

8. Alberta Department of Economic Development, Alberta Heritage Savings Trust Fund and Economic Development Strategy. (unpublished), July 2, 1982, p. 2.

9. Alberta Department of Economic Development (September 1982), op. cit., p. 5.

10. See Government of Alberta, Proposals for an Industrial and Science Strategy for

Albertans 1980-1985. July, 1984.

11. Bruce Rubinger, "Industrial Innovation: Implementing the Policy Agenda", Sloan Management Review. M.I.T.: Vol. 24, No. 3, Spring 1983, p. 43.

12. Science Council of Canada, Hard Times, Hard Choices: A Statement. Ottawa, 1981, p. 65.

II. High Technology Industries

A. Introduction

This chapter examines the nature of high technology industries and reviews the performance indicators that have attracted the attention of economic development strategists. The first section provides a working definition of high technology industries, followed by a clarification of terms central to the discussion and an outline of the relationship between innovation and research and development. The final section reviews the performance of high technology industries by examining the following factors: growth rates, employment generation, export sales, entrepreneurship, and foreign investment in Canada.

Defining High Technology Industries

The term 'high technology' has been used very loosely, taking on different meanings to different groups. The Science Council of Canada generally defines the high technology sector as that group of firms which employs a large number of technicians, engineers, and scientists who carry out Research and Development (R&D).[1] In contrast, the Connecticut High Technology Council simply defines the high technology sector as "any industry that is going to create jobs in the 1980's and 1990's".[2]

Glasmeier et al. (1983) note a significant misconception about high technology industries in that much of the existing literature tends to treat them as a homogenous group. These authors found the high technology sector to be very broadly based, encompassing 29 industrial groups which employed greater than the American national manufacturing average of scientific and technical occupations.[3] Thurow (1984) further addressed the complexities of defining and categorizing high technology industries now that many high technology processes are being adopted by low technology industries. He cites the automobile industry's use of industrial robots in the production process, and questions whether this industry should now be categorized as high technology.[4] At the other extreme, Markusen (1983) notes that approximately two-thirds of all jobs in the computer software sector in the United States are low skilled clerical and service occupations, exhibiting characteristics of a low technology industry.[5] It is for these reasons that Browne (1983b) views high technology as a concept rather than a set of industries that can be defined by the Standard Industrial Code (S.I.C.). Browne does, suggest, however, that high technology is broadly based noting that both innovative characteristics and routine production processes are found within most industries, although some are more technically sophisticated and innovative than others.[6] These examples lend support to the Glasmeier et al. senario and further demonstrate that the high technology sector is very complex and diverse.

Bollinger et al. (1983) argue that there is no clear-cut definition of high technology firms. However, their research focusses on new technology firms which represent a sub-group of the high technology sector. New technology firms are distinguished by two characteristics: first, they are founded by individuals or groups of technological entrepreneurs; and second, they are indpendent in that they do not include subsidiaries of large firms.[7] In Canada, Steed (1982) labels these technology companies 'threshold firms', although his definition is narrower than Bollinger's, describing only medium-sized Canadian enterprises (100-2499 employees) that have emerged from small aggressive firms in this country's most technology intensive sectors.[8] However, both definitions are used to describe indigenous firms which are founded to commercially exploit a technically innovative idea and derive benefits from research and development expenditures.

New technology firms are receiving increasing attention from analysts because they are the most cost efficient performers of R&D. Peters and Waterman (1982) cite a National Science Foundation study which found that new technology firms (less than 100 employees) in the United States produce about four times as many innovations per research and development dollar as medium-sized firms (100-999 employees) and about twenty-four times as many larger firms (greater than 1,000 employees),[9] while accounting for only 5% of all research and development expenditures in that country.[10] They have also made a major contribution to generating and maintaining employment in North America and Western Europe, even during a period of high unemployment. Despite these redeeming characteristics, new technology firms, as defined by Bollinger et al., make up only one component of the high technology sector. Subsidiaries of larger firms are often excluded from the high technology literature, perhaps because of the successes achieved by new, independent high technology firms over a relatively short period of time. Large multi-plant firms spend more money on research and development, possess better knowledge of production and markets and in many cases are the sources of ideas or knowledgeable individuals that result in the founding of new technology firms. Failure to recognize these larger firms and their subsidiaries in any discussion would exclude a significant component of the high technology sector. It is, therefore, the intent of this study to view the high technology sector in broad terms as set out by Glasmeier et al. and Browne. Firms involved in basic and applied research, research and development in new and existing product/process areas, specialized manufacturing and business services were included in determining Alberta's high technology sector.

Clarification of Terms

Although significant differences of opinion about high technology industries remain among most analysts, it is generally agreed that the high technology sector continues to be successful because it is innovative and carries out relatively high levels of research and development. These terms, as well as associated expressions often connected with high technology industries require clarification.

Innovation:	In general, the initial introduction of a new product and/or the first utilization of a new production process. An innovation always rests upon an invention, that is, on a new knowledge which is translated by the innovator into economic activity.

Diffusion:	Diffusion is the information transfer between the inventor and innovator, and between innovators. It includes research and development, production, marketing, and distribution. It may also refer to the widespread adoption, purchase and use of new techniques or products. In this study, the latter definition applies to this term.
Research and Development	R&D is generally defined as investigative and experimental work carried out to acquire new scientific and technical knowledge, to devise and develop new products and processes, or to apply newly acquired knowledge in making technically significant improvements to existing products or processes.
Basic Research:	Original investigations for the advancement of scientific knowledge without specific commercial objectives. It is carried out for the most part by universities, but can also be conducted by government laboratories, the private sector and non-profit research organizations.
Applied Research:	An investigative process directed toward the discovery of new scientific knowledge having specific commercial objectives with respect to products or processes.
Development:	Non-routine technical activity concerned with translating information by the firm into commerical products or processes.
Offensive R&D	An offensive approach involves attempts to be ahead of competitors in new product development.
Defensive R&D	A defensive approach attempts to protect an established market and technological position by developing imitative-type new products.
Research Park:	(Also known as a Research & Development Park or Science Park) An industrial land development that links an academic institution or major research facility involved in scientific research with the business community. Uses are restricted to science-related research efforts with activities such as sales offices, warehouses, and ordinary manufacturing plants not being permitted.

Survey Terms:

Independent firm:	a firm which is headquartered inside Alberta
Canadian subsidiary:	a firm which is controlled by a parent company headquartered elsewhere in Canada
Foreign subsidiary:	a firm which is controlled by a parent company headquartered outside Canada.

Note: Branch plants, which are not incorporated as separate firms, have been classified as subsidiaries in this study

Innovation and Research & Development

Many economic analysts have argued that innovation is the crucial element for the survival of many industries. It is cited often as the reason behind corporate success stories in western developed countries, and when companies fail to be innovative, the whole economic process can slow down or even decline.[11]

It is generally accepted that innovation provides a basis for economic growth, and is related to productivity, employment, and competitiveness in both domestic and international markets. Therefore, to enhance innovative activity may lead to an improved overall economy.

High technology industries are envisioned as consisting of highly competitive, innovative firms, whose activities will spur economic growth, diversify the economy and create employment.[12] In addition, they have been cited as being necessary for providing innovative ideas, products, and processes essential for rehabilitating older, declining industries.[13] These expectations have attracted the attention of all levels of government in western developed countries, many of which are viewing high technology industries as the solution to their economic problems. However, the innovation process is not easily understood and is only now receiving considerable attention.

Schott (1981) notes that innovation is so diverse that it is impossible to develop any single measure of inovative activity. Research and development expenditures serve as an indicator, but represent only one part of the innovation process.[14] However, Malecki (1979) maintains that a commitment to R&D is fundamental to the innovation process.[15] Thwaites (1978) arrived at a similar conclusion noting that the low level of R&D performed by many firms in Northern Britain significantly reduced the probability of technological advance.[16]

Steed (1982) found that innovation is difficult to analyse because it may be influenced by a wide range of complex economic, cultural and behavioural factors, as well as government policies. Furthermore, it can emerge from several sources including corporate R&D, private investors, universities, research organizations and government research facilities.[17] On the other hand, Ellin (1981) concluded that R&D does not necessarily spawn viable innovation, although it has been documented that the incidence of product innovation is greater among firms performing internal R&D.[18] Many successful innovations have been initiated by market appraisal and recognition of technical feasibility, which inevitably draws problem-solving R&D. Success of these organizations is often dependent on the firm's ability to attract or retain high quality technical personnel, while at the same time maintaining close communication between R&D and marketing divisions.

Many studies have demonstrated that investment in R&D contributes significantly to the overall success of both small and large high technology firms. Howells (1984) reviewed a study compiled by Branch in 1974 that showed an important link between rising corporate profits and previous R&D conducted by one hundred large firms in the United States during the period 1950-1965. [19] In a more recent study of high technology startups, Kao (1983) noted a strong correlation between financially successful firms and concerted R&D efforts. Unsuccessful firms were found to carry out little or no research and development.[20] In a comparative study of small high technology firms in Scotland, South East England, and the San Francisco Bay Area (including Silicon Valley), Oakey (1983a) measured the incidence of product innovation. Although the survey confirmed that the San Francisco Bay Area produced the highest rate of product innovations and Scotland the lowest, it is significant to note that 22.2% of the firms surveyed in Scotland performed no R&D as compared to only 8.3% in the

San Francisco Bay Area.[21]

It has been argued that only firms generating a substantial cash flow can support a sizeable R&D effort. Many firms are unwilling or unable to borrow funds to support investment in full-time R&D activities, although it has been found that technological entrepreneurs in smaller high technology firms often conduct in-house R&D on a part-time basis.[22] However, investment in R&D carries a high degree of financial and technical risk, which explains why all businesses are generally cautious toward supporting R&D that cannot be readily commercialized. Schott notes in a comparative international study that five out of every ten R&D projects fail in product and market tests, and only two go on to become commercially successful, for an overall success rate of 20%. [23]. Recent problems of public firms in Canada and the United States reflected in their stock prices, indicates that even growing firms can run into difficulties. Thus, it is evident that economic considerations, that is, initial cost of the innovation, payback periods and rate of return on capital invested, are the most important factors in the technological innovation process. In addition, profitable product innovation requires not only investment in R&D, but the ability to manufacture and market the products.

Howells identified three main categories of R&D: Basic Research, Applied Research and Development. A summary of their characteristics in relation to the firm are shown in Table 2.1. McKenna et al. (1984) found that very few high technology firms actually undertake much basic research.[24] Basic research is generally carried out by university and government research laboratories because the costs are high and returns cannot be recouped by private sector firms. This form of research generally benefits the overall economy more than the individual firm and it is for this reason that high technology firms are more concerned with applied research and development. Applied research and development aim at transferring the technological advance derived from basic research into a new product/process innovation capable of being brought to market. The ultimate goal of the firm is to increase profitability from the innovation, which is dependent on the behaviour of domestic and international markets, as well as competitors.

TABLE 2.1

TASK ENVIRONMENT CHARACTERISTICS OF THE MAIN CATEGORIES OF R&D

Type of Research	Degree of Orientation*	Presence of Commercial Objectives	Payback Criterion
Basic	Minimal	Low	Long-Term
Applied	Medium/High	High	Medium-Term
Development	Medium/High	Medium/High	Short-term
Type of Research	**Operational Time Horizon**	**Degree of Uncertainty**	**Barriers to Entry**
Basic	Long-Run	High	High
Applied	Medium-Run	Moderate	Medium
Development	Short-Run	Low	Low

* Degree of Orientation refers to how relevant the research activity is to the current health of the company.

Source: J.R.L. Howells, "The Location of Research and Development: Some Observations and Evidence from Britain", Regional Studies. Vol. 18 No. 1, February, 1984. p. 22.

Performance of High Technology Firms

Government leaders are attracted to high technology industries because of this sector's remarkable growth rates and alleged job-creating potential. Some analysts further believe that high technology industries can revitalize declining regional economies by stimulating business development and diversifying the economic base. In this section the performance of high technology industries is reviewed by examining the following factors: growth rates, employment generation, export sales, entrepreneurship, and foreign investment in Canada. This information is critical to the province of Alberta, which seeks to improve and expand its scientific and technological base, while increasing its awareness of the factors which contribute to the success of high technology industries.

Growth Rates

High technology industries are envisioned as a group of firms that produce goods and services which are in demand, creating a general trend for rapidly rising sales and net revenues. The rapid growth generated by these firms provides not only a base for future growth and expansion but tax dollars at all government levels. In addition, high technology industries have been characterized by low discontinuance rates. Discontinued firms are defined "as those which were unsuccessful, as well as those which can no longer be found and are presumed to be discontinued".[25] In their study of Silicon Valley, California, high technology firms, Bruno and Cooper (1982) noted a very low average discontinuance rate of 9.2% every four years during the period 1969-1980. This rate is considerably lower than the two out of every three new firm failure rate in the United States after the first four years of founding, as tabulated by Dun and Bradstreet.[26] Overall, discontinuance rates were found to vary considerably between different high technology categories, ranging from 0% for semi-conductor firms to 28% for the broadcast and studio sector.[27]

In contrast to the American example, Knight (1983) cites a Canadian entrepreneurial study conducted by Litvak and Maule (1972), which found that only 15%

of the independent high technology startups surveyed were successful, while 30% were projected as having some chance of success and 55% resulted in failure. These results were based on interviews with forty-seven newly established high technology firms involving ninety-six entrepreneurs from all regions in the country. Failures were typified by problems throughout the organizational structure of the firms. Lack of entrepreneurial initiative and competence in marketing, finance, personnel and manufacturing were all identified as being responsible for the large discontinuance rate found by this survey.[28] This study was subsequently updated by Litvak and Maule in 1980. Their original firm success rate projections were confirmed with twenty out of the forty-seven firms (43%) classified as financially successful companies. Succesful firms were found to generate rapidly rising annual sales growth by concentrating marketing efforts where they were able to maintain a competitive edge, thus avoiding direct competition with larger companies.[29]

Bollinger et al. cite several American high technology surveys, all of which show remarkable growth rates in terms of sales, net revenues and tax dollars. Particular strength is exhibited by the microelectronics industry, which according to Bessant (1982) is characterized by low initial costs of innovations, fast payback periods and high returns on capital invested.[30]. As evidence of these characteristics, the American semi-conductor sector grew at a rate five times that of the country's gross national product and the integrated circuit industry grew almost eighty times faster during the period 1963-1973.[31]

In Canada, Steed interviewed the Chief Executive Officers of twenty-four 'threshold firms' in the electrical products, transport equipment and chemical sectors to determine their growth and profitability. While it was learned that several firms achieved above-average profitability, relative to domestic competitors and the Canadian manufacturing average, Steed noted that firms achieving very rapid growth did not necessarily attain high profitability. Mitel Corporation, an Ottawa-based high technology telecommunications firm, which has produced a steady line of innovative products, is proving to be such a case. In 1982, Steed called Mitel "a bright star"[32] because of its enviable growth record. Many economic analysts also regarded Mitel as a model Canadian high technology company. Between 1973 and 1981, the company managed to double its gross revenues every year. Net profit during this period did not keep pace, but was maintained at a relatively healthy 13 to 15% of sales.[33] During the period 1981-1984, gross revenues increased six-fold but profitability declined rapidly, and the company is now incurring financial losses.[34] Despite record revenues, Mitel is not generating a high enough return on its investment, that is, profitability crucial for R&D investment in the next cycle of innovation. Failure to generate the necessary capital or obtain an equity infusion could have resulted in the demise of the company. The financial infusion subsequently arrived in June 1985, from foreign-based British Telecom P.L.C., which will gain control of Mitel.[35]

The example of Mitel Corporation demonstrates that growth rates can be misleading if comprehensive financial data are not analysed. While many arguments have been advanced attempting to explain the company's swift and sudden decline, we can only speculate as to the internal and external factors responsible for stalling Mitel's growth. However, McKenna et al. note that in many high technology areas, complete product life cycles occur rapidly, which can delay or reduce profitability.[36] Oakey found that product life cycles can be as short as five years in duration demonstrating the importance of R&D for improving or replacing existing products and ensuring growth of the firm.[37] Some high technology sectors, for example, computer software, depend on their R&D capacity to give them a one or two month advantage over competitors.[38]

As a result of this intense competition, rapidly changing technology can significantly alter product life cycles. These factors suggest that initial growth rates exhibited by many high technology companies like Mitel Corporation may be difficult to sustain and may in fact become more erratic over time.

Employment Growth

Employment growth is, perhaps, the most controversial issue in the high technology debate. Because of their tendency toward rapid growth, many economic analysts argue that high technology industries are prolific creators of new jobs.[39] However, some critics believe that high technology job projections have been overstated,[40] while one analyst has bluntly forecast that "there are no jobs in high-tech". [41] To complicate matters further, Browne (1983b) states that it is extremely difficult to project high technology employment growth because forecasts prepared by various government agencies use different definitions of high technology and different assumptions of overall economic growth.[42] Breheny et al. (1985) (in Hall and Markusen) further elaborated on this problem identifying significant differences between American and British data sources, the nature of high technology industries and occupational composition when attempting to compare employment growth.[43]

Goddard (1983) claims that employment change can vary between regions because of differences the in industrial structure and mix of firms located within a given area. For example, certain office functions may be eliminated in subsidiary firms because they can be more readily provided through high technology communication systems from the company headquarters located elsewhere.[44] McCracken (1983) notes that jobs will be lost in the short-term from the introduction of new technology, but that most economic analysts are in agreement that increases in productivity are related positively in the medium and longer term to increases in growth in the economy and employment.[45] However, Weiss (1985) (in Hall and Markusen) cites an article by Business Week (1981) that predicts 25 million current jobs in the United States will be eliminated during the next two decades. He concludes indirect job loss due to high technology will greatly outweigh direct job creation and that the outcome for many communities may be devastating.[46] Similarly, in Britain, Storey (1981, 1983) counters that in Britain only small firms have been prolific creators of new employment and that those jobs are unlikely to be sufficient in replacing those being shed by larger firms. However, he estimates the chances of a new firm that will show substantial and continued growth in terms of employment, that is, having one hundred employees within a decade, is one in 150.[47]

Hall and Markusen (1985) argue that it is not from employment that high technology will make an impact but from profits of high value added products and services which will raise the levels of efficiency of all firms and industries. Examples such as National Semiconductor Corporation's ability to recently increase its silicon water output by 64% while still employing the same number of people at the same skill level, tend to support this view.[48] Despite these conflicting arguments, it is becoming more apparent that failure to introduce new products and processes will eventually lead to a loss of competitiveness, which will ultimately result in a decline in employment.

Past employment trends in the United States show that high technology industries accounted for 75% of the jobs created in the manufacturing sector from 1955-1979.[49] Subsequent review by the United States Office for Technology Assessment (1984) also showed positive employment trends. In their analysis of two secondary surveys in sixteen selected states during the period 1975-1980, it was found that high technology employment grew faster than overall manufacturing employment for the nation as a whole in both survey groups and in every individual state.[50] Survey data were further analysed between 1978 and 1980 because these years represent part of a recessionary cycle. These results indicated contrasting trends. The first set of surveyed states showed that high technology employment growth was sufficient to offset a decline in manufacturing employment, while the second group of states experienced a real decline in high technology jobs.[51]

Glasmeier et al (1983) suggest it is dangerous to generalize about high technology job growth because high technology industries produced widely divergent employment growth rates during the 1970's. Computer and petroleum refining were found to be the highest generators of new jobs, while smaller and more specialized scientific instruments posted the highest percentage employment growth rates. On the other hand, certain industries in the defense, aerospace and communications sectors exhibited net declines in employment growth rates. While no distinct reasons were offered to explain the widely divergent growth rates, it was suggested that substitution of new commodities for old ones resulted in job growth in some sectors, while displacing jobs in others.[32]

Markusen et al. (1983, 1985) selected four prominent high technology sectors that have contributed to high rates of employment growth: computer software, photovoltaics, biogenetics, and robotics. Employment trends in these sectors were reviewed and it was generally concluded that although substantial new jobs will be created in these areas, they may not be sufficient to offset the decline of jobs in other sectors. In addition, it is believed that present employment gains and labour shortages in key technical areas will diminish and may even reverse as these high technology sectors mature.[33]

The types of jobs associated with high technology employment are often presumed to be stable, well-paying positions. This belief stems from the enormous amount of literature that identifies scientists, engineers and technicians as comprising the core of positions in high technology industries. These types of jobs require skilled personnel. However, the majority of unemployed workers are unskilled, which suggests that without retraining programs, high technology firms will not absorb significant numbers of unemployed workers. The structuring of retraining programs may not be an easy task as Weiss (1985) (in Hall & Markusen) contends that a displaced worker would have to undertake from two to ten years of education and training to become qualified for many of these positions.[34] While there is little doubt that types of skilled employment are a component of the high technology employment structure, scant attention has been paid to the production stages and subsequent impact on jobs. Some analysts argue that high technology industries are no different from textile manufacturing and automobile assembling in that they cannot compete with the low wages and low manufacturing costs of Southeast Asia. Although many American high technology companies have been manufacturing in Southeast Asia for many years, Atari Inc. was one of the first major American companies to abandon U.S. manufacturing.[15] Atari Inc. is a well-known producer of electronic video games and had been a prolific producer of new jobs over a short space of time.[16] However, in February 1983, the company announced its intention to transfer its video game manufacturing plants to Hong Kong and Taiwan, where wage and benefits average $1.20 U.S. per hour. Existing manufacturing plants in California's Silicon Valley were closed, putting out of work 1,700 production workers earning about $9.00 U.S. per hour [17]. More recently, Tandon Computer Corporation and Seagate Technology Ltd., two emerging computer companies, closed their American disk-drive manufacturing plants and moved them to the Far East. While some analysts have argued that the transfer of manufacturing operations to the Far East may satisfy short-term goals, a loss of quality control along with engineering and marketing problems related to the introduction of new product lines may result, which can hurt a company's position in the long-term. Nevertheless, investment bankers and financiers have encouraged many companies to relocate their manufacturing operations to Southeast Asia, which in the case of Seagate Technology Ltd. was considered necessary because the firm "couldn't compete effectively at home."[18]

These examples may indicate the beginning of a trend to move high technology production facilities to Southeast Asia, which will ultimately have a negative impact on employment. Should such a trend proliferate, Canadian competitors may have no option but to follow suit.

Export Sales

Governments have traditionally encouraged exports as a means of enlarging the domestic industrial base and increasing employment. Recent studies have suggested that innovative technology firms are successful in export markets and that there may be a correlation between research and development expenditures and export sales. The Economic Council of Canada surveyed 150 firms to determine the relationship between R&D spending (as a proportion of sales) and exports (as a proportion of sales), with an emphasis on newly developed products. It was found that those firms engaged in high levels of R&D were twice as likely to have high export sales.[39] Similarly, an American Electronics Association survey (1978) of seventy-seven firms founded between 1971 and 1975 showed that for every $100 of equity capital invested in 1976, $33 was spent on R&D and $70 in export sales was generated.[40]

Hanel and Palda (1982) noted that the most successful rates of export growth were achieved by Canadian companies doing their own innovating. Their study found that export opportunities were reduced for companies importing their own technology and were the lowest for foreign-owned firms relying on the transfer of new ideas from their parent companies.[41] However, the relationship between research and development expenditures and export sales was found to be not as significant as the marketing and management of the firm. In addition, export sales usually did not begin until strong domestic sales had been achieved, in part as a result of diffusion of the innovation to international markets. Similar results were also found in another Canadian study conducted by McGuiness and Little (1983) (in Bollinger et al.). Their study suggests that management skills and the entrepreneur's ability to penetrate foreign markets may be more directly related to increased export sales as opposed to increased research and development expenditures.[42] Management skills were also credited by Tsurumi (1984) as being responsible for the competitiveness exhibited by Japanese firms in export markets. He found that Japanese executives had received extensive schooling in domestic and international sales operations and were thoroughly familiar with their firms' products and international markets.[43]

Entrepreneurship

Entrepreneurial activity is responsible for generating both new and untried ventures but it is also found in large firms and in some cases, government. Many authors have defined different types of entrepreneurs and the roles they play in entrepreneurial activity. High technology entrepreneurs are generally technically oriented, relying on their innovative abilities more than their managerial and administrative skills. The performance, as well as the characteristics of these entrepreneurs, represent important factors behind the success or failure of high technology companies.

Perhaps the most comprehensive study examining high technology entrepreneurial activity was carried out by Roberts and Wainer (1968). They examined not only the performance of new technology spin-offs from private research laboratories and the research facilities at the Massachusetts Institute of Technology (M.I.T.) but also identified key characteristics of the local entrepreneurs and the organizational and managerial factors which enabled them to establish successful new enterprises. Entrepreneurial characteristics were generally found to correspond with previous research results, that is, entrepreneurs were frequently the children of self-employed fathers, possessed a well-rounded education, considerable technical experience, and were driven by a need to achieve.[64]. In addition, entrepreneurs were found to be development rather than research oriented and were more often part of a team of two to five people rather than an individual.[65] The new spin-off firms were generally created with technology transferred from the entrepreneurs' former place(s) of employment, which were comprised mainly of vigorous microelectronics and computer industries along Boston's Route 128. The more successful firms were distinguished by the following characteristics:

1. Entrepreneurs prepared a comprehensive business plan[66] that recognized the importance of management skills and specific business talents. If lacking, management expertise was brought into the organization. Loftin (1983) identifies management background and expertise and not the product (or service) an entrepreneur is trying to sell as being the most important concern of the venture capitalist. Most investors believe high calibre management with a mediocre product will succeed more profitably than a mediocre management team with a high quality

product[67]

2. Importance was placed on personnel matters and concern for employees (perhaps as a result of firm raiding or fear that technical staff may leave and start their own firm). It is interesting to note that personnel matters occupy a major portion of management time in prominent high technology corporations like International Business Machines (I.B.M.) and Texas Instruments.[68]

3. Formal marketing groups were established for promoting and selling the firms' products. Other important responsibilities most likely included: evaluating market potential, costs of penetrating markets, and assessing the competition.

Overall, it can be concluded that the successful entrepreneurial firms surveyed by Roberts and Wainer generally achieved a balance of strength between management, R&D, marketing, and production. Canadian research has generally shown that this level of organization and management expertise is lacking among domestic entrepreneurs. For example, the Litvak and Maule (1972) study found that only one out of every five independent Canadian high technology firms surveyed had a satisfactory marketing organization and that 85% of the firms introduced their innovations into highly or moderately competitive markets.[69] The inability of Canadian entrepreneurs to incorporate management and marketing expertise into the firm's overall strategy and structure have been cited as major reasons for the large number of high technology firm failures in this country.[70] The result, according to Grieve (1972), is that the aggressive Canadian entrepreneur capable of preparing a comprehensive business plan and assembling a competent management team is very scarce.[71]

Although most spin-off firms surveyed by Roberts and Wainer showed superior market adaptability, the complete process from the original technical work through to the establishment of the new firm, to successful diffusion of its innovation, resulting in significant growth, accounted for six years of time lag.[72] This time lag indicates a relatively short gestation period, but may be explained by the rapid growth experienced by the microelectronics and computer industries in the study area. Only very few locations have been able to achieve these kinds of results. The United States Office of

Technology Assessment indicates a minimum of twenty years may be a realistic time period for a location to develop to a stage where local jobs and products can be credited to the efforts of local entrepreneurs.[73]

Foreign Investment in Canada

Foreign investment has long been claimed to be a barrier to the development of high technology industries in Canada. The issue received much attention as a result of the conclusions determined by the Federal government sponsored Watkins Report (1968) and the Gray Report (1972). The role of foreign investment has been further addressed by Britton and Gilmour (1978) who claim that Canada has failed to develop an innovative capacity because of 'truncation' through foreign ownership"[74] A truncated firm, which may also be known as a branch plant or subsidiary, relies on the parent firm for many of the functions associated with innovation, that is, from original research through to all aspects of production and marketing. Because a subsidiary firm is not autonomous, R&D decisions are not made within a Canadian context, but instead with reference to the corporation as a whole. The outcome for Canada can be reduced exports, import dependence in manufactures and skilled services, lack of a trained, highly skilled labour force and negative effects on the demand for skilled Canadian workers. In addition, it has been argued that high levels of foreign ownership result in an uneven geographic distribution of industry, a drain on the Canadian balance of payments through management fees and dividends paid to parent companies and in the loss of technological leadership due to relatively low levels of corporate research and development.[75]

Britton (1980) argues that Canada is technologically underdeveloped, in part due to the high level of foreign ownership. Foreign-controlled subsidiaries were found to perform less R&D than domestic firms and were more likely to be slower in implementing technology change. In addition, the technology received from the parent firm tends to be mature, with the proceeds from sale used by the parent to develop new technologies.[76] Rugman (1981) contends that such business practices are not irregular because foreign firms operate in Canada to secure a larger market for their products, not to transfer technology to this country. Technology transfer to subsidiaries carries the risk of loss of technological and management skills, which in part accounts for centralizing R&D functions near the parent headquarters located outside the country and further explains why innovations occur in the home nation as opposed to the host nation.[77] Nevertheless, the low levels of R&D performed by foreign-controlled subsidiaries remains a contentious issue. A study conducted by the Science Council of Canada also found that foreign-controlled subsidiaries perform less R&D per dollar sales than Canadian-controlled companies,[78] although they receive a greater share of government grants for R&D than Canadian firms.[79] Britton further argues that foreign investment must be reduced and replaced with measures that support domestic innovation and larger R&D output. However, Palda and Dazderka (1982) counter than foreign-owned firms must be viewed individually because some foreign subsidiaries maintain high levels of R&D expenditures, while others do not.[80] McMullen (1982) expressed concern not with the level of R&D expenditures, but with how they are allocated. He suggests that foreign subsidiaries are too conservative, embarking on defensive R&D programs designed to improve products or processes which have been proven in the market, as opposed to offensive R&D, which attempts to develop new products and processes with greater technical and financial risks.[81] However, it can be argued that most firms, regardless of their ownership, do not attempt such an offensive strategy, but innovate to defend their existing market positions.[82] McMullen further suggests that foreign-controlled subsidiaries play a positive role in the process of technological change in Canada, noting that they have an edge with respect to innovation over domestically-controlled companies.[83] For example, I.B.M. (Canada) makes a positive contribution to the Canadian high technology sector by developing and exporting certain types of high technology products. This company's expertise in new technology development, ability to handle R&D expenses, and knowledge of markets, could not have been provided by domestic Canadian companies. However, large foreign-controlled corporations like I.B.M. Ltd. may be exceptions to the rule. Steed maintains that only a few foreign-owned corporations have an inhouse and design capability necessary for a world product mandate and the generation of exports.[14] Control of technology and design, along with access to export markets are fundamental to export performance. The majority of foreign-based high technology firms in Canada do not have this mandate, relying instead on technology and research transfer from their parent firms. Nevertheless, Steed and DeGenova (1983) in their study of high technology firms in the Ottawa-Carleton region, found that foreign-owned subsidiaries generated a slightly higher level of exports than domestic Canadian companies.[15] Based on evidence reviewed above, this finding could be, perhaps, as a result of better management.

A major concern in the foreign investment issue in Canada is that strategic corporate decisions are made at the parent firms' headquarters located outside the country. While the corporate strategy of the parent firm determines investment (including levels and location of R&D expenditures), product, technologies and the location in which its subsidiaries will operate, the Federal government has played an important role in persuading foreign-controlled firms to establish product lines at their Canadian-based subsidiaries. In addition, the Foreign Investment Review Agency (F.I.R.A.) was established in 1973 to screen applications from foreign companies attempting to establish Canadian subsidiaries or acquire ownership of Canadian firms, and to require applicants to enter an agreement such as to increase research and development expenditures, as a condition for approval.[16] Because F.I.R.A. is perceived by many economic analysts to be hostile to foreign investment, the current Federal Conservative government has indicated a preference for dismantling the agency or altering its mandate.[17] The intention is based on the premise that foreign investment is necessary to stimulate the economy out of its current recession and promote further growth. This approach represents a reversal in direction from the "Canadianization" policies of the previous Liberal government. Despite the shared view by Canadian and foreign financial communities that F.I.R.A. represents an abandonment of the free enterprise system, Valaskakis (1983) suggests the requirements of this agency are not unreasonable, given the high level of foreign ownership in Canada and that most other countries, including the United States, have established far more stringent foreign investment regulations than Canada. It should also be noted that most of the applications received by F.I.R.A. are granted approval,[18] suggesting that claims identifying this agency as being hostile to foreign investment may be exaggerated. It has been argued that foreign investment in Canada can lessen competition by preventing a potentially innovative Canadian company from developing and penetrating internationial markets. However, Canadian high technology foreign investment is a topic that is often overlooked when discussing foreign investment in this country. Companies like Northern Telecom Ltd., Gandalf Technologies Ltd., Lumonics Group, and Mitel Corporation Ltd. have made great strides in penetrating international markets and establishing foreign-based subisidiaries. Mitel, for example, has established subsidiaries in Puerto Rico, Great Britain, Netherlands, West Germany, Italy, Japan, New Zealand, Hong Kong and the United States during its relatively short corporate history.[19] From this perspective, it is apparent that foreign investment has not constrained the growth of many Canadian-owned high technology firms, which suggests that the foreign-ownership issue may be over-stated. The foreign-ownership debate might best be summarized in the words of Dr. Stuart Smith, Chairman of the Science Council of Canada:

> "Let's worry less about ownership of the company and worry more about its behaviour. If we have tax incentives, concessions or grants to offer then, they should be available to Canadian or foreign owners, provided that those companies are willing to go out into the world and compete on behalf of Canadians".[20]

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b. Management Organization, including functional responsibilities and resume of key personnel.
c. Market survey, assessment of total size of market, competition, and risks.
d. Development plan for product and service including schedule and cost production.
e. Manufacturing Plan, including schedule and cost production.
f. Marketing and Service plan, including schedule and cost projections, market penetration and pricing strategy.
g. Cash flow and earnings projections.
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III. Locational Determinants of High Technology Industries

A. Introduction

This chapter provides an analysis of the important locational determinants of high technology industries by examining high technology development elsewhere. The first section examines the research park, which historically was the first type of facility introduced to encourage high technology development. The now famous "Silicon Valley", "Route 128" and "Research Triangle" are highlighted to determine the factors which contributed to their success. A general review of Canadian research parks follows and the section is concluded with a brief analysis of research park failures. The second section investigates the locational diversity of high technology industries by providing examples of emerging high technology regions that show no evidence of geographical clustering in research parks. The final section provides a summary of recent locational survey literature and outlines the most important locational influences found by these surveys.

Research Parks

The establishment of the first research parks, that is, in Silicon Valley California, and along Route 128 in Massachusetts, were for the most part, private sector initiatives. It was the success of these parks that prompted various levels of government in North America to introduce research parks as a regional economic policy tool to aid and attract high technology industries. Historically, the development and promotion of the research park was the traditional approach to establishing a regional economic base for high technology industries in North America.

In this section, a historical review of the research park beginning with Silicon Valley and concluding with Canadian cases is provided. The intent is to analyse, compare and discuss factors contributing to the success or failure of research parks and to determine whether or not a common formula for establishing the successful research park exists.

The research park concept involves linking an academic institution or major research facility involved in scientific research with the business community for the purpose of aiding and attracting high technology industries.[1] It differs from its industrial park counterpart in that zoning tends to be much more restrictive[2], with emphasis on science-related efforts. Activities such as sales offices, warehouses and ordinary manufacturing plants are not permitted uses. [3] Clearly however, in Silicon Valley and along Route 128, manufacturing and assembly plants have sprung up in close proximity to research parks. The research park continues to be envisaged as a technology complex, employing an array of scientists, engineers and technicians, all involved in basic and applied research. Expectations are that innovation generation, sparked by intensive research and development activity will promote industrial growth, maintain competitiveness, diversify the economic base and enhance employment opportunities. Such expectations were first realized by the now famous "Silicon Valley", located near San Francisco, California. This success story sparked a scientific and economic boom in its region and served as a model for the development of research parks across North America. Prominent research parks subsequently evolved near Boston, Massachusetts (Route 128) and in North Carolina (Research Triangle). Research parks have been successfully established in several other regions in the United States, but none have grown as rapidly or as large as in the three regions mentioned above.

By 1967, there were 126 research parks in the United States and Canada, with an estimated occupancy rate of only 27%. [4] Ninety-nine of these parks were established by realtors, land developers and municipalities, and many carried the title research park to promote a positive image for what were essentially speculative developments.[5] The growing number of competitive locations saturated the market, resulting in the failure of many parks.

Hayter and Gunton (1983) acknowledged a more recent study completed during the 1980's which identified only eighty-one research parks in North America, but with an average developed occupancy rate remaining at a low 37%.[6] Despite the poor overall success rate of existing research parks, the spectacular growth of Silicon Valley, Route 128 and the Research

Triangle has encourged further study of the attributes of these developments in the hope of determining common location factors. These factors could then be used to devise comprehensive regional policies for establishing successful high technology research parks in their own geographic areas. The trend to develop research parks continues and has more recently spilled-over to Western Canada, where new develpments have been introduced in Alberta, British Columbia and Saskatchewan. It is generally accepted that these latest additions are patterned after the successful American parks discussed hereafter.

Silicon Valley

Silicon Valley is located in Santa Clara County, near San Francisco, California. The original research park was established by Stanford University in 1951 for the purpose of complementing the university's engineering programs and providing sites for new and expanding technological companies in the San Francisco area.

The park started out slowly, supporting only seven companies by 1955, thirty-two by 1960 and fifty-seven by 1967.[7] Rapid growth was experienced over the next seventeen years, resulting in the development of a 51 park technology complex that now supports approximately 1,800 high technology firms concentrated in an area fifty by twenty kilometres.[8] It is now the seventh largest industrial region in the United States, specializing in electronics, computers, aerospace and defense related industries. The work force totals some 230,000 people, with a recent annual growth of 20,000 employees.[9] Several authors disagree about the factors responsible for stimulating high technology activities in Silicon Valley. Hayter and Gunton (1983) note that growth occurred not as a result of government polices, but instead from the initiative of private sector entrepreneurs who maintained a close contact with Stanford University.[10] This conclusion was based on the findings of the Joint Economic Congress of the United States location study of high technology firms completed in 1982. However, the Joint Economic Congress study also concluded that there was no conscious planning by area businessmen. Instead, development occurred in a haphazard manner, coinciding with growth in the electronics industry. The electronics industry was established in the state as early as 1917, but developed rapidly when the Federal government injected $35 billion into the California economy for defense-related purposes during World War II.[11] While the Silicon Valley owes its early support almost entirely to military contracts, Danilov (1967) claims that Stanford University played a major role by deliberately setting out to establish a technology-based economy on the university campus.[12] Dorfman (1983) generally supports this view, but concludes that it is difficult to measure the extent to which the university was actually responsible for the growth that occurred there. Dorfman does, however, recognize the pioneering role of Frederick Terman, a professor of electrical engineering at Stanford, whose idea it was to develop a research park on the Stanford campus.[13] Terman hoped to attract technology firms that would interact with the university, as well as elevate the level of the engineering faculty. He was not only responsible for fostering industry-unversity co-operation but was extremely successful in attracting public and private sector financing and encouraging students to start their own firms. As a result, Terman was able to attract the first semi-conductor firm to the park in 1954 and assisted young entrepreneurs in the founding of many new companies including Hewlett-Packard Ltd. and Varian Associates Ltd.[14]

The combination of attracting major firms to locate in the park, the founding of new companies by Stanford graduates and the creation of spin-off firms by scientists and engineers leaving established companies, produced the pattern of development of high technology firms in Silicon Valley. This pattern of development was subsequently altered by extensive merger and acquisition activity as revealed by Bruno and Cooper in 1982. In their sample of 250 firms founded between 1960-1969, it was learned that 32.4% were acquired or merged with other companies by 1980.[15] The acquiring company was often a publicly-owned firm headquartered outside the Silicon Valley region. While the authors cite numerous reasons for the large number of mergers and acquisitions, it was concluded that these activities contributed to continued growth in Silicon Valley during the 1980's by bringing in additional financial and managerial resources needed to compete in rapidly growing markets. In many cases the selling entrepreneurs were freed to start the process all over again by becoming venture capitalists or founding new companies.[16]

Route 128

Route 128, located near Boston, Massachusetts, is the second most noted concentration of high technology firms in the United States. The early beginnings of this high technology complex contrast with Silicon Valley in that the two nearby renowned academic institutions, the Massachusetts Institute of Technology (M.I.T.) and Harvard University, did not directly participate in the original park's inception. However, graduates from these academic institutions did provide the most important sources of entrepreneurs in the region by establishing new high technology companies and subsequently providing employment for future engineering graduates. Private developers capitalized on the demand for industrial land along Route 128, resulting in the establishment of sixteen parks by the late 1970's.[17]

Dorfman notes that high technology development at Route 128 was indigenous, based mainly on the growth of new firms and that "its emergence was virtually spontaneous, unabetted by efforts on the part of local interest groups or government .....".[18] The success of new enterprises and spin-off companies is well documented by Roberts and Wainer (1968) whose comprehensive study into new firm development along Route 128 showed a failure rate of only 20% over a four to five year period, as compared to a national average of 50% over a two year period.[19] However, the role of government and local interest groups perhaps, may have been understated by Dorfman. It is evident that the participation of M.I.T. and Harvard in research and development was crucial to the stimulation of technology growth, as well as the successful transfer of technology to private industry. Furthermore, the injection of government funds for defense-related contracts during World War II, as witnessed in Silicon Valley, acted as the catalyst for high technology growth and continued to play an important role in the region's development during the post-war period. By 1982, 30% of the income received by Route 128 firms was generated by government defense contracts.[20] With respect to local interest groups, several venture capital companies affiliated with M.I.T. and Harvard, and the local financial community played an important role in financing the development of new firms.

Silicon Valley & Route 128 Compared

The pattern of development of these two high technology regions is remarkably similar. Both areas developed during the same time period, emerging from a well-developed science and technology infrastructure, and resulted in the creation of thousands of new firms that achieved remarkable growth rates. The stimulus for high technology development was the result of private sector entrepreneural initiative not any explicit government policies. In fact, government laboratories were the weakest incubators of new firms, perhaps because of their lack of market orientation or because of low levels of employee interaction with private sector counterparts.

According to Dorfman, the growth of these young companies to the stage where they dominate their respective regions is the most significant similarity. Virtually all of the firms are associated with electronics stemming from post-World War II growth in transistors and computers, and today both regions produce specialized electronic instruments, computers and associated software. The only major difference is that firms located on Route 128 are heavily concentrated in the research, design and development of minicomputers and do not engage in the production of integrated circuits. In contrast, Silicon Valley is the world's largest producer of semi-conductors and integrated circuits, which led to the development of the silicon chip.[21]

The high technology firms of Silicon Valley and Route 128 have tended to spatially concentrate in a relatively small area, perhaps because many are in early stages of corporate development. Clustering in certain locations has enabled these firms to monitor competitors and draw employees from a specialized labour pool. More importantly, the firms are located close "to the centres of action",[22] allowing them to quickly obtain information relating to the latest product and market developments in a rapidly changing industry.

The United States Office of Technology Assessment cites three significant factors which have contributed to the success of research parks in general, but perhaps apply even more to these two case examples:

1. Skilled Labour Force
2. University-Industry Interaction
3. Availability of Venture Capital [23]

While the role of the adjoining academic institutions and their skilled graduates has been previously discussed, it should be emphasized that a symbiotic relationship between academic and business communities existed. M.I.T. and Stanford have consistently led the United States in terms of academic quality in the fields of electrical engineering and computer science, and Harvard possesses the nation's most respected business school. These reputations are enhanced by the close ties maintained with private industry. Nearby corporations support a significantly greater proportion of on-campus research at these universities compared to the national average, thus illustrating the importance of university-industry relations.[24]

The availability of venture capital played a major role in the development of new high technology firms in both research parks, particularly between 1970-1980. During this decade, Massachusetts and California were the only two states that consistently attracted a positive inflow of venture capital.[25] Although Hambrecht (1984) claims there was a willingness to finance risk ventures in California as opposed to a more conservative financial community in Boston, it was the initial successes of firms in Silicon Valley and Route 128, sparked by growth in revenues and earnings, which served to attract capital investment funds from other regions as well as international sources.

In addition to these factors, Malecki (1980, 1984) stresses that recreational and cultural amenities, which contribute to a quality lifestyle, cannot be overlooked. He concludes that these amenities are provided only by large metropolitan urban areas and that scientists and engineers prefer locations like San Francisco and Boston where these opportunities are offered.[26] Previous behavioural research conducted in Britain by Buswell and Lewis (1970) concluded that environment — that is, recreational and cultural amenities, schools and housing — was the single most influential factor for attracting and retaining scientists and engineers.[27] However, the high technology location survey conducted by Glasmeier et al. suggests that cultural amenities and lifestyle offered by large urban areas may be overstated. Not only are the large urban areas which possess the greatest cultural and recreational advantages not attracting net job growth in high technology industries, but nine of the top ten metropolitan areas in the United States in terms of percentage of labour force in high technology industries are small to medium-sized centres.[28] These findings suggest that a trend toward decentralization in the location of American high technology firms may be taking place. In addition, Dorfman notes that negative externalities in the form of high land and housing costs can result in areas of intensive high technology industrial expansion. The prime example cited is the expensive Silicon Valley real estate market, which has hurt recruiting programs by numerous area firms, causing some establishments to relocate. [29] Other factors such as high wages, high taxes, excessive regulations, congestion and lack of room for expansion have also been cited as reasons for moving facilities to other regions, further suggesting that both Silicon Valley and Route 128 may be approaching full development capacity.[30]

Research Triangle Park

The Research Triangle park is located between the cities of Raleigh, Durham and Chapel Hill in North Carolina. Established in 1959, the research park comprises 2,225 hectares (5,500 acres).[31] The growth and development of this park contrasts considerably with Silicon Valley and Route 128 in that the State government planned the park and guided its development. The site was originally intended to be developed as a large industrial complex, but was instead transformed into a research facility to provide in-state employment for graduating students from the three neighbouring universities: North Carolina State, University of North Carolina and Duke University.

Co-operation between the State government and the three area universities led to the creation of the Research Triangle Foundation, a non-profit research affiliate to the universities, which was followed by the state sponsored North Carolina Science and Technology Research Centre. Constructed in 1963, this research centre was the first government facility designed to encourage scientific research and technological application in North America.[32]

The strong linkages between the research park, State government and the three universities led to a hard-sell promotional approach to establish a high technology community. Most regions have been traditionally involved in attracting industries from outside their jurisdictions and this approach was favoured because of its immediate visible impact. The relocation of an established firm provides recognition and prestige, and may serve further to attract other firms.[33] This objective as achieved in part by 1965, when I.B.M. Ltd. announced its intention to locate both research and manufacturing facilities in the park.[34] Other large corporations were subsequently lured to the research park and to date nearly all high technology activity consists of branch plants from large corporations.[35] A list identifying the research park's top ten corporations ranked by employment size is shown in Table 3.1. It is significant to note that these firms carry out a wide variety of high technology research and are not concentrated in any one category.

Factors contributing to the success of the Research Triangle Park are summarized as follows:

1. Critical Mass of Educated and Technical Workers

   The region's three universities provided the scientists and engineers considered necessary for attracting high technology companies and their research facilities. In addition, education was given priority by the State government, resulting in a reorganization of the community college network and strengthened technical programs. The educational improvements assisted in providing a strong base of technical workers.[36]

2. Labour Cost and Availability

   The United States Joint Economic Congress study identifies labour cost and availability as important criteria that influence the choice of location within a region.[37] The study also ranked this region first in terms of labour cost and availability in the United States, enhancing its attractiveness for high technology production facilities. Manufacturing wages in 1982 averaged $13,949 compared to $17,194 nationwide, and only 14% of the labour force are unionized compared to 25% in the nation as a whole.[38]

TABLE 3.1

TOP TEN RESEARCH TRIANGLE PARK OCCUPANTS RANKED BY EMPLOYMENT SIZE

	Occupant	No. of Employees	Research Activity
1.	International Business Machines Ltd.	5,000	Telecommunications Equipment
2.	Northern Telecom Ltd.	1,500	Digital Switch Equipment
3.	U.S. Environmental Protection Agency	1,500	Human Health Research
4.	Research Triangle Institute	1,200	Contract Research
5.	Burroughs Welcome Co.	1,035	Pharmaceutical Research
6.	National Institute of Environmental Health Sciences	600	Biomedical Research on Chemical/Biological Agents
7.	Northrop Services Ltd.	390	Environmental Research
8.	Monsanto Triangle Park Development Centre	250	Synthetic Fiber Research
9.	Data General Corp.	230	Computer R&D
10.	J.E. Sirrine Company	210	Engineering Services

Source: Joint Economic Congress of the United States, Location of High Technology Firms & Regional Economic Development, (Washington), 1982, p. 48.

3. Park Location

The research park is strategically located between all three academic institutions. The strong linkage between the universities and the business community has made the region attractive to many high technology firms and the prime location allows for easy access to existing university research facilities

4. Quality of Life

North Carolina's 'sun belt' location is perceived by many companies as offering an attractive lifestyle and a relatively low cost of living.[39]

5. Integrated Promotional Efforts

The Research Triangle Foundation is responsible for administering the development process within the park. Close co-operation is maintained with the local community and key university departments, which both actively participate in the promotional efforts of the research park. This strong and well-organized promotional approach to the development strategy represents a logical extension of traditional economic development efforts. The success of the programs in attracting high technology industries is unparalleled with any other region in North America. The overall result has been that North Carolina has successfully integrated high technology industries into its economic base.

Canadian Research Parks

In Canada there are ten research parks in various stages of development. A list of these parks is shown in Table 3.2. It is significant to note that of these ten research parks, eight have been introduced since 1980, suggesting that research parks have only recently gained prominence in Canada as an industrial development option. As a result, literature concerning the development of Canadian research parks is scarce, with much of the preliminary background research being conducted by McAlister (1983).

While the Silicon Valley is often referred to as the prototype for research parks in Canada, closer examination reveals that all ten parks were deliberately established having received direct and extensive participatory support from respective provincial governments. This pattern of development is clearly more comparable to the Research Triangle, and supports the assumption that research parks can be publicly planned. The analogy to the Research

TABLE 3.2

CANADIAN RESEARCH PARKS

Name	Date Established	Location
Sheridan Research Park Community	1964	Mississauga, Ontario
University Research Park	1965	Calgary, Alberta
University of Victoria Discovery Park	1980	Victoria, B.C.
U.B.C. Discovery Park	1980	Vancouver, B.C.
Simon Fraser University Discovery Park	1980	Burnaby, B.C.
B.C. Institute of Technology Discovery Park	1980	Burnaby, B.C.
Innovation Place	1980	Saskatoon, Sask.
Calgary Research & Development Park	1980	Calgary, Alberta
Edmonton Research & Development Park	1981	Edmonton, Alberta
University of Waterloo Research Park	1983	Waterloo, Ontario

Source: Adapted from Ann McAlister, Canadian Research Parks: A Preliminary Analysis, (Unpublished Thesis), Department of Geography, University of Waterloo, 1983, p. 35.

Triangle was first cited by Hayter and Gunton in their recent research into British Columbia's 'Discovery Parks', but it is becoming increasingly obvious that virtually all Canadian research parks evolved from the 'Research Triangle' model. Despite this similariity, Canadian research parks, on average, are in area no more than 5% of the size of Research Triangle Park and support only a fraction of the number of firms. In general they are also significantly smaller than their American counterparts, being less than 50% of the average sized American park.[40] Although there is little evidence to indicate the optimum size of a research park, the much smaller Canadian parks supporting substantially fewer firms are in significant in terms of their impact on regional economies.

Sheridan Park Research Community

The Sheridan Park Research Community, located near Mississauga Ontario, is Canada's first and largest research park. The 137 hectare site (340 acres) was established in 1964 by two provincial Crown agencies: the Ontario Development Corporation and the Ontario Research Foundation. Sheridan Park is perhaps, Canada's most successful research park, although nearly 50% of the existing site remains undeveloped. McAlister notes that present tenants are primarily multinational corporations which have located their research facilities there. However, it is important to note that resource-based companies including such firms as Abitibi-Price Ltd. (pulp and paper), Cominco Ltd. (base and precious metals mining), Gulf Oil Canada Ltd. (integrated oil company), and INCO Ltd. (base metal mining), comprise the largest proportion of the tenant mix.[41]

The Ontario Research Foundation was the nucleus for the Sheridan Research Park and it continues to be a strong linkage. It undertakes research, development and other technical investigations on a confidential basis at its large research facility.[42] Promotional information also stresses that nine universities and several community colleges are available to prospective businesses and that all are within easy driving distance. The extent to which firms located in the park interact with local academic institutions has never been assessed. However, the lead role played by the Ontario Research Foundation suggests that proximity to the area's academic institutions was not a significant location factor taken into consideration by firms established in the park.

Western Canadian Research Parks

Of the eight research parks established after 1980, seven are found in Western Canada: four in British Columbia, two in Alberta and one in Saskatchewan. In general terms, all of these parks share the same development objectives:

1. To diversify the provincial economies by strengthening the provinces' weak technological capabilities.

2. To encourage local entrepreneurs to establish new firms.

3. To attract high technology firms from other regions.

Because these parks are in an embryonic stage and possess different organizational structures and operating procedures, it may be premature to assess their performance to date. However, Hayter and Gunton pose the question: "Where are the entrepreneurs who will set up activities in the (Discovery) parks?"[43] This question is fundamentally important to the research park strategy whether discussing British Columbia's 'Discovery Parks', Innovation Place in Saskatchewan or Alberta's Research and Development Parks because each of these provinces possess a relatively narrow economic base. While Ironside (1977) notes that government incentives in targeted growth centres can assist in stimulating entrepreneurial activity, he does acknowledge the difficulties in creating an environment conducive to entrepreneurship.[44] Provincial governments have failed to address how entrepreneurship will be encouraged within their provinces. In Alberta, a draft Science and Technology Policy directed at entrepreneurship generation was not introduced until four years after the Calgary and Edmonton Research Parks were established. As a result, park administrators reverted to traditional means of attracting high technology firms from outside the province. To date, the Calgary Research Park has not yet attracted any firms, while Edmonton has been successful in luring Bell Northern Research Ltd., a subsidiary of Bell Canada Enterprises Ltd. and Northern Telecom Ltd. More recently, four local high technology firms have located in Edmonton's research park. Strong promotional efforts continue at both Alberta locations, but appear to lack an integrated approach to development as witnessed at North Carolina' Research Triangle. However, the initial "teething" problems of establishing an administrative organization and technical support facilities have, perhaps, delayed the implementation of comprehensive marketing strategies. Current promotional efforts in Calgary contrast considerably with that City's University Resesarch Park, established in 1965. Its tenants are comprised of large locally-based oil companies, which were encouraged to locate their energy related research facilities near the University of Calgary.

Research Park Failures

While considerable attention has been given to the success of Silicon Valley, Route 128 and the Research Triangle, the significant number of research park failures has generally gone unnoticed. Analysis of park failures in the United States has been highlighted primarily by Danilov (1967, 1971) who concluded that only one out of every four research parks achieved successful results.[45] Examples of significant attempts to deliberately establish research parks that ultimately ended in failure include: Panther Hollow at the University of Pittsburgh and Miami University's International Research Centre. The Panther Hollow project was continually plagued with financial and administrative difficulties and park organizers failed to involve the local business community. In contrast, Miami University possessed a weak engineering faculty that was unable to attract industry support.[46] These two examples demonstrate that merely locating in close proximity to a university does not assure success and that the much sought after formula for establishing viable research parks is more elusive than what was originally thought. In Canada, it is too early to assess the success rate of existing research parks. Most locations have only been recently introduced, but given the growing number of competitive locations, particularly in Western Canada, it can only be concluded that these parks are speculative ventures. This writer's view is more cautious than McAlister who concluded that "Canada's research parks will emerge as successful entities."[47]

Locational Diversity of High Technology Industries

It is becoming more evident that what works in one region may not work in another, perhaps as a result of regional and cultural diversities, as well as a series of specific but complex site location factors. Differences have been noted, particularly in Western European cases, where the research park has not yet been successfully transplanted, despite several attempts to do so. Although those academic institutions engaged in high research activity like Stanford and M.I.T. provide strong locational attractions for high technology companies in the United States, Buswell and Lewis found no clear-cut physical proximity between universities and high technology industries in Britain.[48] Subsequent to the Buswell and Lewis study, research parks with strong university ties emerged in Cambridge, Warwick, and Edinburgh. Nevertheless, Goddard and Thwaites (1983) note that despite the presence of universities of equal quality dispersed throughout Britain, the majority of innovative firms are located in the southern half of the country.[49] An analysis of product innovations introduced between 1960-1978 further revealed that a large proportion of them could not be traced back to university research. [50] Oakey (1981) accounts for the weak high technology locational attraction to British universities on differences between the British and American university systems. British universities, unlike their American counterparts, generally do not offer research facilities which place importance on commercially relevant research as opposed to basic research. Instead, British firms conducting external R&D rely heavily on contracts with local academics and consultants.[51] Oakey does, however, maintain that the university-industry linkage is important to the development of high technology firms, adding that the university does not necessarily have to be a world class institution. This importance is reflected by the recent British high technology literature which emphasizes strengthening the university-industry linkage through fostering technological inovation as opposed to developing research parks near university campuses.

In Scotland, it has only been very recent that the eight universities located there have become involved in joint research efforts with high technology companies. Although the government sponsored Scottish Development Agency promotes Scotland as 'Silicon Glen', existing firms are not found in established research parks, but are instead scattered across Scotland's central belt.[52] Similarly, a study of high technology firms in the Netherlands found no evidence to support geographical clustering as found in American parks.[53]

In Canada, the Ottawa-Carleton area has emerged as this country's most prominent high technology region. It has been dubbed 'Silicon Valley North', although the estimated 300 high technology firms operating in the area are scattered throughout the region.[54] Most of these companies are 'spin-off' firms whose origins were traced by Steed to three major sources:

1. Computing Devices of Canada: an Ottawa firm established in 1948 whose activities concentrated on military projects and therefore required close proximity to the Federal government.

2. Government R&D laboratories of the National Resarch Council

3. Private R&D laboratories of Bell Northern Research Ltd. Bell's research labs were located in Ottawa due to the presence of the Federal government and because the city was close to the parent firm's headquarters in Montreal.

Many of the 'spin-off' firms created from these sources have benefited from the presence of the Federal government, a skilled labour force and the technical and information resources provided by the National Research Council. Although the City of Ottawa possesses two well-known universities (University of Ottawa and Carleton University), these institutions did not play a significant role in the establishment of high technology firms within the region.[55]

The tendency for some high technology firms to cluster in research parks yet disperse in other areas suggests that the locational behaviour of high technology industries is more complex than was originally thought. Glasmeier et al. studied high technology location patterns in the United States between 1972 and 1977, and found significant inter-industry patterns of concentration and dispersion across several high technology sectors. Defense and aerospace firms were found to be extra-ordinarily concentrated in relatively few areas, primarily as a result of large expenditures of government funds.[56] Resource-based firms were also found to be spatially concentrated, but for different reasons. In some cases, demand from a resource sector was found to draw industry to few locations, while in others, supply of a raw material seemed to account for concentration.[57]

At the other extreme, a set of relatively mature producer goods sectors, for example chemicals and fertilizers, were found to be highly dispersed, producing heavy or bulk material inputs for groups of dispersed industrial or agricultural producers. Market orientation was cited as the factor contributing to dispersion.[58]

The most innovative and fastest growing high technology industries were found to be moderately dispersed. However, significant variations among this group were noted. Some sectors, for example computers, showed increasing tendencies toward greater decentralization, while others such as semi-conductors became futher concentrated. The authors suggest that product cycles affect innovative fast growing companies causing them to initially cluster in areas of successful entrepreneurial activity and skilled labour pools. Once the product is standardized, greater efforts are concentrated on marketing, which tends to cause dispersion. Further intense competition and market saturation may result in relocation to areas of lower labour costs. While the Atari example previously noted supports the product cycle theory and related findings were identified by the United States Office of Technology Assessment, the authors of this American study were unable to test these hypotheses. With respect to those sectors which were found to further concentrate, it was concluded that this trend was the result of selected plant closings and the transfer of operations to larger scale plants in new or existing locations.[59]

The complex and diverse locational characteristics exhibited by high technology industries have proved frustrating to the various levels of government in North America and Europe which have attempted to recreate those conditions presented by the highly visible and successful American research parks. To date, most regional programs directed at establishing research parks have met with little success, further illustrating that the research park is only one method for establishing high technology industries. Once believed to be critical for the nurturing of high technology companies, the three prominent American "research parks" are now being viewed as unique and not the "norm".

A major fault in the underlying assumption supporting the establishment of research parks is that high technology industries have been traditionally perceived as a homogenous group of firms that require an industrial park-like facility to carry out research activities. As a result, various government authorities regarded the location requirements of high technology industries to be not much different from those of general manufacturing. This misunderstanding about the characteristics and location requirements of high technology industries remains prevalent in several government sponsored high technology development programs in Canada and the United States For example, the United States Office of Technology tudy (1984) revealed that twenty-two states have some form of development program designed to attract high technology industries to their regions. However, many of these programs are not distinct from economic development in general, which has resulted in attempts to attract any industry that will locate in their region. These findings demonstrate a lack of understanding about high technology firms in general and are leading to a reassessment of the factors that contribute to the success of high technology firms and the type of government policies which may be effective in stimulating and supporting high technology development.

Review of Recent Locational Survey Literature

The purpose of this section is to review further and discuss the locational determinants of high technology industries. While several important location factors have been determined already from analysis of the various successful and unsuccessful research parks, several comprehensive surveys dealing with high technology industries in general, have been completed by researchers attempting to gain a better understanding of the characteristics and location requirements of high technology firms.

In recent years, research has been directed at defining and analysing the spatial pattern of high technology industries. Many studies (Buswell and Lewis 1970; Gibson 1970; Oakey 1981; Steed 1982) identified high technology industries as 'footloose' because they could not be analysed in terms of classical location theories; that is, transportation, access to raw materials and access to markets are not major locational determinants. A survey of high technology companies in the United States conducted by the Joint Economic Congress Committee supports this conclusion and further notes that factors such as water resources, energy supplies and climate are also not important locational determinants.[40] However, discussion below of the need for skilled labour, specialized support sources, venture capital information, R&D and entrepreneurship indicates that the traditional term 'footloose' may be not an accurate description of high technology firms.

Malecki (1979) determined that the availability of a well-educated labour force tends to attract and ultimately generate agglomerations of research and development. For example, government laboratories provide the locational focus for firms that rely on government contracts, while universities provide basic research facilities as well as opportunities for interaction in a non-corporate setting. Corporate organization also plays an important role in location of firms actively engaged in research and development because R&D tends to be conducted near the company's headquarters for closer linkage with overall corporate policies. Potential R&D projects receive intensive screening from executive personnel prior to approval for greater co-ordination and monitoring of programs and expenditures.[41]

Buswell and Lewis suggest that proximity to international airports for direct linkage to other cities is an important locational determinant. Their study found that locational requirements resemble those of central office activities in that inputs and outputs are primarily informational in character, that is, the quick movement of highly qualified personnel between laboratories, research organizations, universities, conferences and company headquarters.[42]

The compound effect is that high technology industries generally favour metropolitan regions where research, headquarters and service functions are common. Both the Joint

Economic Congress survey and the study completed by Glasmeier et al. support the locational preference of an urban environment. However, Glasmeier et al. emphasize that the presence of high technology industries does not necessarily ensure an expansionary future. Between 1972-1977, it was found that one-third of the 277 metropolitan areas in the United States lost high technology jobs.[43] In addition, regional anomolies in plant and employment gains and losses, from which no significant patterns emerged, were noted in several prominent metropolitan centres.

The most significant factors that influence the regional location choices of high technology firms appear to be business-related. While the regions are principally interested in attracting high technology firms in order to aid the generation of regional economic growth, locational choice by the companies is more concerned with the volume, quality and cost of research output. The Joint Economic Congress study found labour skills and their availability, labour costs and tax climate within the region as the most important factors affecting high technology location. Glasmeier et al. cite labour force, proximity to airports and defense spending as the most important factors. In both studies, proximity to major universities ranked fourth. Bollinger et al. cite a study conducted in the Netherlands (1980) which asked firms to rank the problems that constrained locational decisions. Shortage of skilled labour ranked highest, followed by increased competition and insufficient capital.

The United States Office of Technology Assessment locational survey of ninety-nine high technology firms was the only study found by this writer which stressed the importance of the home of the founding entrepreneur as the most improtant location factor. Proximity to existing operations ranked second, followed by availability of a skilled labour force. Other important factors included access to the firm's market, local transportation resources and government sponsored support programs. Proximity to university facilities tied for seventh rank. [44] A summary of the findings of these locational surveys is illustrated in Table 3.3.

The United States Office of Technology Assessment survey is significant because it focusses attention on the importance of the relationship between entrepreneurial activity and

TABLE 3.3

FACTORS THAT INFLUENCE REGIONAL LOCATION PREFERENCES OF HIGH TECHNOLOGY COMPANIES: SUMMARY OF LOCATIONAL SURVEYS

Joint Economic Congress Survey (1982)		**Congress of the United States Office of Technology Assessment Survey (1984)**		**Glasmeier *et al.* Survey (1983)**		**Bednarz's Texas Locational Study (1984)**	
Rank	**Factor**	**Rank**	**Factor**	**Rank**	**Factor**	**Rank**	**Factor**
1	Labour Skills/Availability	1	Founding entrepreneurs lived there	1	Labour Force	1	Proximity to airports
2	Labour Costs	2	Close to existing operations	2	Airports	2	Good highway access
3	Tax Climate	3	Labour Skills/Availability	3	Defense Spending	3	Room for future expansion
4	Academic Institutions	4	State Government Support	4	Universities	4	Professional and Technical Labour
5	Cost of Living	5	Local Transportation	**Netherlands Locational Study (in Bollinger *et al.*, 1980)**		5	Labour Costs
6	Transportation	6	Quality of Life			6	Proximity to large urban centres
7	Access to Markets	7	High Technology Business Climate	1	Shortage of Skilled Labour		
8	Regional Regulatory Practices	7*	Universities	2	Increased Competition		
9	Energy Cost/Availability	9	Availability of Suitable Sites	3	Lack of Venture Capital		
10	Cultural Amenities	10	Overall Business Climate				
11	Climate	11	Financial Incentives				
12	Access to Raw Materials	12	Venture Capital Availability				

7* Tied for seventh rank.

the location of new technology firms. It suggests that innovative activity within regions is dependent on a local supply of technologically motivated entrepreneurs whose personal influence have a significant bearing on locational decisions. Experience from several locations which have achieved successful high technology development generally support this conclusion. In Silicon Valley, Cooper (1970) found that at least one founding entrepreneur had resided locally prior to company formation in 97.5% of the firms surveyed.[65] In Britain, Oakey, Thwaites and Nash (1980) studied the spatial distribution of 323 significant product innovations. In a large majority of cases, first commercial production was achieved in the same region as the inventor firm.[66] In Canada, Steed and DeGenova surveyed forty-five high technology firms in the Ottawa-Carleton region. A total of forty-one firms were founded by entrepreneurs with strong local associations. The remaining four companies were locally established, but were later acquired by foreign-owned firms. Despite the strong personal attachment to the Ottawa area, many of the executives surveyed indicated that they could operate satisfactorily in several dispersed cities across the country.[67]

The United States Office of Technology Assessment notes that in 'true high technology centres' there exists a 'critical mass' which enables the entrepreneur to capitalize on various support mechanisms including both information systems and venture capital. Peripheral locations are perceived to be at a disadvantage because they do not possess a 'critical mass' and lack important information linkages. In addition, venture capitalists in urban areas are reluctant to invest outside their regions because they may not be familiar with the situation of a firm located far away. Nevertheless, it is recognized that regions have different levels of entrepreneurial activity, some of which favour high technology development, but many of which do not. This factor may serve to explain why local and regional economic development authorities direct their greatest efforts at attracting subsidiaries of large high technology firms. For some communities it may be the only alternative. Communities like Colorado Springs, Colorado and Austin, Texas have recognized these external constraints, adapting their market strategies specifically toward attracting high technology branch plants. The development of new branch plants helps create a base for building a technical infrastructure which, over time, can attract additional high technology operations and encourage spin-offs.[68]

The successful results achieved by cities like Colorado Springs and Austin contrast considerably with Storey's survey of low technology branch plants in Cleveland County, located in the north of England. He found that large, externally-owned branch plants produced few entrepreneurial spin-offs, offered little opportunity for the development of local managerial talent and bought relativley few inputs form local area firms. Overall, it appeared that indigenous industrial performance had been suppressed rather than stimulated.[69]

These findings suggest that long-term intra-regional growth based on attracting branch plants is dependent on the ability of such firms to innovate, act as incubator firms to new enterprises and interact with existing local firms, factors which growth pole theory has not always initiated in practice.[70]

In order for a high technology development program based on luring branch plants to be effective, a community must identify its ability to attract and service prospective firms, prepare an appropriate strategy that emphasizes existing strengths, and implement a set of policies that will encourage private sector participation. Success of local programs can often depend on the co-operative role played by local business groups and municipal government agencies in designing and implementing these programs. The commitment shown by local interest groups to high technology in general was cited by Microelectronics and Computer Technology Corporation[71] as the major factor behind its decision to locate in Austin, Texas.[72] However, further analysis has shown that "local commitment to high technology" translated into an enormous financial incentives package that was funded primarily by Texas oil money.[73] While it is not argued that Austin assembled a comprehensive high technology development strategy, the financial support received from locally based oil companies enabled that city to outbid its competitors. The Microelectronics and Computer Technology Corporation example may be unique, but it is concurrent with Goddard's view that the amount of mobile investment available is declining and the competition and cost of attracting new investment are increasing.[74] This trend suggests that a strong case can be made at the local level for development programs that encourage innovation in indigenous firms. While it is evident that sustained local initiatives are crucial to stimulating high technology growth, it is important to recognize that the most substantial results are produced when local efforts are linked with broader development strategies implemented by senior levels of government.

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IV. Technology & Innovation Policies

A. Introduction

This chapter provides a review and discussion of the types of policy mechanisms presently used by higher levels of government to stimulate innovation and technology development. The first section examines the 'Picking the Winners' strategy, a popular but controversial concept that favours the targeting of government support to technologically emerging firms. The second section reviews the various types of policies designed to promote innovation. Although the intent is to focus specifically on Canada, the discussion is supplemented with related findings from other western developed countries.

Picking the Winners

The limited success attained by regional development programs directed at establishing research parks that would attract high technology industries has, in many cases given way to new approaches for the stimulation of economic growth. Technology and innovation policies are receiving more attention, in part because of a lack of new proposals for economic growth and because innovation is perceived as being crucial to the survival of many industries. Several authors (Oakey 1979; Ewers and Wettman 1980; Steed 1982; Storey 1983) stress that the ultimate aim of regional policy oriented toward innovation should be to promote indigenous growth by targeting support at small to medium-sized technology firms. This strategy is directed at 'picking the winners' as opposed to propping up the losers in troubled or dying industries.

Thurow (in Steed 1982) notes that "an industrial policy designed to prop up dying industries is a route to disaster. We need only to look at the countries that have tried it (Britain and Italy). No one can make it work".[1] At the opposite extreme, Japan has achieved success in identifying potential winners in competition for world markets by encouraging their growth, while at the same time easing the burden of adjustment for declining industries. The Japanese

Ministry of International Trade & Industry works closely in co-operation with business leaders and the financial community to deliberately plan the direction in which the economy should be evolving. Tax, loan, trade, regulatory and other policies designed to guide economic growth along the desired path are subsequently adopted. In the high technology sector, Japanese firms are the recipients of a strong commitment to R&D, investment subsidies and support for technical education.[2]

Some economic analysts suggest Japan's industrial policy is overstated, pointing out that it has had its share of high technology failures, and that other countries like West Germany have fared equally as well without a national policy for backing potential winners. Instead, Japan's strong economic performance is credited to a productive, lower cost labour force and the skill of its managers and entrepreneurs.[3]

While various levels of government in several western developed countries have expressed interest in the'picking the winners' strategy, economist Ry George of Dalhousie University in Halifax has expressed caution about supporting such a strategy in Canada because it could potentially."saddle the country with infant industries that would grow into permanent invalids."[4] He further stated that "Canada's record contains horror stories of governments' supporting companies at least in part because a good future was forecast for them."[5] A recent government of Ontario discussion paper on the future of technology further argued that declining industries cannot be neglected because "a number of Canadian industries (for example clothing and textiles) believed to be on their death-beds are already being rejuvenated by new technologies."[6] The remarkable turn-around of Chrysler Corporation is a case in point. According to Rees et al. (1984) the resurgence of the American manufacturing sector can be attributed to a continuous retooling process being carried out by older plants in established manufacturing area. Through the adoption of new product and process technology, the level of technological progress is being raised, which enables firms to remain competitive. However, it was further observed that innovation adoption varied significantly between industrial types, the type of company, size and age of plant and by the presence or absence of R&D. [7] In any case, the critical problem of identifying potential winners and determining which losers (if any) should be saved still remains.

In Britain, Storey attempted to predict business failures rather than pick potential winners. His research showed that 85% of all sampled failures could have been predicted twelve months in advance of the collapse and 73% could have been predicted three years in advance.[8] It was concluded that if a technique for predicting business failures could be refined a more selective screening process for directing assistance to potential winners could be established.

Steed concedes there is no simple way of identifying potential winners, but suggests that measuring a firm's past performance, its technology strategy and the role of government in supporting or stimulating the firm's innovation provides valuable direction.[9] Using these criteria, he found Canada's potential winners among five technology intensive industries: electrical, chemical, machinery, transport equipment, and petroleum and coal products. These sectors account for in excess of 75% of all research and development expenditures in Canada[10] and, according to Steed, offer major sources of innovations. Although the importance of the R&D-innovation relationship is stressed by the "Threshold Firms" scenario, Steed further argues that R&D cannot be viewed in isolation, but instead must be examined within the context of government policies to support innovation.

Government Policies to Promote Innovation

In 1971, the Science Council of Canada produced a report entitled "Innovation in a Cold Climate". The report's principal recommendation was that the federal and provincial government, in collaboration with industry and the universities, prepare a national industrial strategy that recognized the importance of the innovation process and gave priority to industries that exhibited highly innovative potential.[11] At present, fifteen years later, Canada is still working toward a national technology strategy that will attempt to stimulate the creation and growth of new and innovative Canadian companies. However, an interim policy statement entitled "Towards 1990: Technology Development for Canada" was produced in 1983. This document outlines the role and objectives for technology development in this country and further highlights current federal support programs and new initiatives.

The federal agency responsible for preparing and implementing policy instruments is the Ministry of State for Science and Technology (hereinafter referred to as MOSST). It has three major responsibilities:

1. To formulate and develop policies for, and to advise on the support of science and technology.

2. To formulate and develop policies for, and to advise on the application of science and technology to national issues

3. To foster the rise of scientific and technical knowledge in the formulation and development of public policy.

A general review of MOSST's current support programs shows a variety of mechanisms that include: procurement, subsidies and loans, tax incentives, information services, technological facilities and patents. These types of mechanisms are similar to those used by most western developed countries attempting to stimulate technology development. Specific federal government support programs are aimed primarily at providing financial assistance for industrial R&D and for the most part are administered by the Department of Regional Industrial Expansion (DRIE) and the National Research Council (NRC).[12]

The National Research Council is the federal government's primary research agency. It is a non-profit Crown corporation that maintains a large scientific library (Canadian Institute for Scientific and Technical Information) and operates research facilities in each of the provinces, except Alberta. In 1980, the NRC produced a long-range plan entitled "The Urgent Investment". The Plan proposed an intensive national technology investment in R&D to assist industry to achieve a doubling of its production and exports by 1990. The federal government supported the stated need for increased levels of R&D expenditures and subsequently approved the Plan in principle in June, 1981.[13]

In 1983, a Federal Task Force composed of university and industry representatives was assembled to review the effectivness of federal government policies and programs for promoting technology development in Canada. Recommendations were based on 300 written briefs and 100 interviews conducted with representatives from business, the federal and provincial governments, and universities. Economic analysts and government agencies in the United States, Great Britain, the Netherlands and the Scandinavian countries were also consulted.

The Task Force found that market factors play a significant role in the innovation process and that technological growth is enhanced when there is a 'demand-pull' by the market as opposed to a 'supply-push' by government.[14] Research and development expenditures are drawn to market demands and perceived needs, which in turn generate succesful innovations over a large number of industrial sectors. R&D is also deemed to be more cost-effective because it is undertaken in response to clearly defined goals. This finding is not radically new as evidence has long suggested that a high proportion of innovations are initially stimulated by consumer demand.[15] However, the Task Force's support for the 'demand-pull' theory represents a significant shift in the approach to stimulating technology development in this country. Many economic analysts and the National Research Council have been critical of Canada's low level of research and development expenditures (about 1% of G.N.P.) relative to other industrialized nations like the United States, Japan, West Germany and Sweden (2-3% of G.N.P.).[16] Although the specific contribution of R&D to national economic growth has not been defined, most economists generally agree there exists a strong correlation between the level of national investment in R&D and the national potential for technological development and economic growth. However, Steed claims it is easy to advocate increased R&D spending, but extremely difficult to compare the benefits and determine the best way to invest available funds.[17] The Task Force subsequently arrived at a similar conclusion directing concern not with the national level of R&D expenditures, but with the effectiveness with which R&D funds are deployed. It is their belief that if Canada doubled its spending on research and development, the economic impact would be marginal due to artificial stimulation.[18]

The Task Force's conclusion may be significant given that the proportion of R&D expenditures by federal and provincial governments has been generally increasing, while the proportion of industrial R&D expenditures has been generally decreasing. In Alberta, combined federal and provincial R&D expenditures accounted for 42% of all R&D investment in 1984 compared to only 21% in 1979. On the other hand, industrial R&D expenditures declined to 33% of all R&D investment in 1994 compared to 55% in 1979.[19] While the Alberta government has stated that it spends more money on R&D than any other province in the country, it remains unclear as to how effectively these funds are being deployed.

Government Procurement

Government can affect the innovation process through its own demand, that is, purchases or procurements from the private sector. Government demand decreases risk and uncertainty, and guarantees a future market. It has already been demonstrated how government procurement in the United States played a significant role in stimulating the development of new technology firms in Silicon Valley and Route 128. Many electronics and computer firms own their existence to government defense and aerospace contracts and although in most cases sales have been expanded to commercial markets, defense spending remains an important stimulus to high technology development.

In Canada, Steed and DeGenova found that many Ottawa-based high technology firms maintained ties with federal institutions. Their study showed that the presence of the Federal government was a key factor in stimulating the initial development of many firms within the area and that 57% of those surveyed considered their geographic proximity to the Federal government to be crucial or significant to the firms' business. Major linkages included defense and other purchases, supply of technical expertise and the provisions of contracts or grants.[20]

The Federal Task Force on Policies and Programs for Technology Development recognized the importance of government procurement in stimulating high technology development, but stressed that policy designed to effectively utilize the Federal government's purchasing power to promote private sector innovation as lacking. Although the Departments of National Defense, Transport, Environment and Energy Mines and Resources purchase hundreds of millions of dollars worth of high technology products and services every year, suppliers are more often foreign-based firms. Government agencies were found to be either unwilling to take a chance on domestically produced alternatives or their contract allocation process generally excluded smaller, innovative Canadian firms.[21] In contrast, the American federal government for several decades has purchased from or arranged contractual agreements with small and newly created high technology companies, resulting in the growth and expansion of numerous innovative firms.

Despite the noted successes of government procurement in stimulating innovation, arguments have been brought forth claiming it is a narrow policy instrument. Bollinger et al. cite a study by Rothwell and Zegfeld (1981) that identify the following limitations:

1. Frequent policy changes initiated by government can increase uncertainty, thereby reducing the probability of market success.

2. Governments lack market power. Therefore, innovation cannot be effectively influenced without supporting measures, such as regulation.

3. Competition may be lacking, thereby reducing the incentive for individuals or groups of potential entrepreneurs from starting new firms

4. Government agencies often lack in-house competence in various high technology areas, which constrains the decision-making process.[22]

As a result of these factors, government may miss opportunities to effectively use procurement to assist high technology firms.

Subsidies

Subsidies are one of the most common forms of government programs designed to stimulate the innovation process. They can take on many forms including R&D support, financial grants and tax incentives.

R&D is one area that receives substantial government support in most western developed countries. Many small high technology firms will not undertake R&D without some form of government incentive because they lack the personnel and financial resources necessary to conduct inhouse R&D. Subsidy schemes assist these firms to conduct at least some research or to contract out their programs to research organizations, consultants and universities.

Financial grants designed to assist new technology firms through the early stages of the innovation process is another type of subsidy program. It is common in Western European countries and can assume a variety of forms ranging from injection of funds into key technology sectors to the funding of projects in the idea and prototype stage.[23]

The effectiveness of these of subsidy programs in stimulating the innovation process remains unclear. Economic analysts have found relatively few differences in economic growth and strength of high technology sectors between those countries which provide little R&D subsidies and those which provide industry with large amounts of public money for R&D.[24] Other analysts, like Schott, have demonstrated that government subsidies can lead to inefficiency by financing high risk, high cost projects that have a great chance of incurring substantial financial losses. He cites the French government's subsidization of that country's computer industry, which turned out to be highly unprofitable.[25]

In Canada, the Federal government has initiated several subsidization programs which are administered by various departments and agencies. In total, the subsidies amount to approximately $500 million annually.[26] The Federal Task Force on Federal Policies and Programs for Technology Development found most programs to be over-administered, with overlapping responsibilities among agencies and complex procedures for evaluating and monitoring applications. In addition, most programs had little to offer new technology firms, instead offering incentives to firms with established track records.[27] In many cases these firms possessed the capability to carry out R&D without federal assistance. Some programs were found to encourage firms to undertake R&D projects that would not have been economical without government assistance or collect public funds for R&D which might have well been carried out without any subsidization.[28] Overall, it was concluded that promoting R&D "by subsidizing the private sector is an approach with serious strategic weaknesses ....".[29]

Tax Incentives

Tax incentives are an indirect form of government subsidy which can be used to encourage industrial R&D. Increased tax credits or write-offs are generally favoured by the private sector in this country[30] and are believed to be an effective alternative to receiving direct subsidies. The Federal Task Force noted that Canada has a generous system of tax measures to encourage R&D. In 1983, the Federal government introduced the "Science Research Tax Credit Program (SRTC), which allowed companies to transfer R&D tax credits to private investors. Originally heralded as a program that would enable smaller high technology firms to more easily attract outside investors for R&D funding, the scheme was cancelled by the newly elected Conservative government in late 1984 because cost of the program had been estimated at $1.8 billion higher than originally projected. Subsequent investigations revealed that the SRTC scheme was abused by several recipients resulting in the auditing of all 1,800 claims made under the program.[31] Despite the well-publicized problems, the SRTC program was popular with many provincial governments which have been lobbying Ottawa to reinstate some form of tax credit for scientific research.[32]

Tax measures help to improve the risk ratio for R&D investment, thereby favouring those small to medium-sized high technology firms that generate taxable revenues. However, it remains unclear as to how effective tax incentives are in promoting innovation and new firm development, although at least one state government (Minnesota) is experimenting with a tax credit program designed to encourage spin-offs from larger companies.[33] In the United States, many new high technology firms viewed tax incentives as one type of measure needed to complement other forms of government support programs.[34] In contrast many large American high technology firms did not acknowledge tax policy as an important factor in their decision-making process.[35] In Britain, a corporate tax reduction was found to stimulate R&D investment more than any other policy.[36] Overall, these findings suggest that tax incentives can play a significant role in stimulating R&D investment, but that their contribution in encouraging innovation and new firm formation is less pronounced.

Science and Technology Infrastructure

Government can establish an infrastructure conducive to high technology development in two ways:

1. by direct intervention in the economy to deliberately establish a science and technology infrastructure.

2. by supporting existing institutions in encouraging innovation and entrepreneurship.

Government intervention in the economy to deliberately establish a science and technology infrastructure is a controversial issue. Buswell and Lewis maintain that governments already have considerable influence over the distribution of research establishments through their own demand for high technology products and processes. However, they further claim that the growing regional competition for high technology development necessitates government manipulation to ensure balanced growth and maximisation of social benefits within the economy.[37] Oakey (1979) counters that any balancing action by government aimed at forcing the dispersion of new products and high technology firms cannot be assured of success.[38] In addition, Ironside argues that 'forced-growth' situations, where public investment attempts to induce industry to locate where normally it would not, can be met with confrontation from the private sector, which prefers its own location. He further concludes that government measures used to persuade industry to establish branch plants in certain locations has not been successful in solving regional disparities and is unpopular with the private sector, regardless of the overriding social, political and economic considerations.[39]

Because regional policy focussing on building an infrastructure by manipulating industrial growth has not been very successful in the past, attention is now being directed at supporting innovation and entrepreneurship as a means for establishing a science and technology infrastructure. A more recent policy initiative has been the introduction of the 'Innovation Centre'.

Innovation Centres

The first innovation centres were introduced during the 1970's at four universities in the United States (M.I.T., Carnegie-Mellon, oregon and Utah), and two in Canada (Waterloo and Ecole Polytechnique de Montreal). Initial funding was provided by Washington and Ottawa but all centres are expected to become self-supporting through participation in their clients' ventures.[40] Universities were chosen as the sites for innovation centres because they perform two major roles in the innovation process. First, they perform basic research, which is put to work by industry. This transfer of technology fosters the commercialization and diffusion of innovations and further identifies problems requiring new knowledge. Second, the flow of people and information between universities and industry expands the base of scientific and technological information.[41] Therefore, forging the university-industry links represents an integral element in the success of the innovation process. In addition to these roles, the innovation centre calls upon the services of many disciplines and functions within the university, particularly those associated with business and engineering and allows for reduced costs by sharing the use of expensive equipment.

Innovation centres are "aimed at promotion of innovation and entrepreneurship"[42] from both an educational and managerial viewpoint. They are designed to encourage innovation by reducing the gap between developing an innovative idea and reaching the stage of commercial production, as well as providing training and skills in entrepreneurship.[43] More specifically, innovation centres perform the following functions:

1. idea/invention evaluation
2. financial and managerial assistance for start-ups
3. development of new products for existing businesses

4. formulation of innovation/entrepreneurship education curricula
5. researching innovation processes
6. participation in entrepreneurial decision-making.[44]

Students and potential entrepreneurs are exposed to a multidisciplinary approach. They learn how to evaluate new industrial ventures, how to keep aware of new technological developments and how to develop a business plan for obtaining financing and ultimately, marketing.[45] The benefits of combining classroom training with real business situations is now recognized by many universities, particularly in the United States. The number of academic institutions offering enterpreneurship programs has risen from less than ten in 1960 to over 200 in 1980 and has doubled since then.[46] Some universities, like Carnegie-Mellon offer co-operative Master's and Ph.D. programs for students employed by industry. Graduate studies directed by both academic and industry advisors are combined with professional work.

The development of the innovation centre for interaction with industry represents a departure from the traditional linkages between universities and industry. Colton (1981) suggests that it encourages the university and industrial communities to move toward a commonality of interest, mutuality of trust and increased co-operation in the area of research and development.[47] Despite this movement toward common ground, Dean (1981) revealed significant problems between small business-university interactions. He noted that great differences exist between small business and academic personnel in perception of the importance of problems, time required to solve problems and cost factors. In addition, plans to solve problems or evaluate new inventions are often rejected by the entrepreneur for fear of competitors learning of the invention and gaining a competitive advantage.[48] Although these problems have not been fully addressed, they emphasize the importance of gaining the confidence of the business community in dealing with the innovation centre. Participation with the business community and other local interest groups is stressed by Walker (1983) in his study of the University of Waterloo Innovation Centre. He maintains that a marketing strategy which familiarizes the business community with the services provided by the innovation centre is essential for demonstrating how this facility can assist their needs. A liaison with local economic development agencies was also encouraged for promoting the research capabilities of the university and innovation centre, as well as assisting new spin-off firms to locate within the region.[49] Recent information suggests that the more specialized innovation centres established by the Ontario provincial government have failed to implement marketing and promotional programs, resulting in a lack of awareness and confidence among the business community.[50]

University-based innovation centres are proving to be important facilities for the transfer of technology to industry and the education-innovation process. Initial results from M.I.T., Carnegie-Mellon and the University of Oregon have received a favourable response from both government and industry analysts.

> "From 1973-1976, these three centres have created and developed 27 new products and given rise to 29 new businesses with the 33 entrepreneurs trained there. The annual turnover of these new businesses was around $30 million in 1976. Some 800 new jobs (direct and indirect) were created and the annual profits that government drew from them in the form of taxes were ten times greater than the grants awarded."[51]

Although statistics later than 1976 are not available for these centres, Walker notes that nineteen firms have been spun-off from the University of Waterloo Innovation Centre during the period 1980-1983.[52]

Li and Blais (1981) claim that in order for an innovation centre to be successful, the host university must be well recognized for its quality of research and academic standing, have a long tradition of close relations with industry, and be "somewhat special" either by tradition and organization or its socio-economic environment.[53] However, the United States Office of Technology Assessment notes that innovation centres are being developed in many smaller, less distinguished universities through the combined efforts of the academic institutions, industry and State governments in initiating co-operative programs for local economic development. In Canada, the Federal Task Force on Federal Programs for technology Development claims that American universities are better equipped for co-operative research ventures with high technology companies, due in part to extensive financial and equipment donations received from industry. Canadian universities generally do not recieve generous donations because of differences in tax laws.[54] Other obstacles which are claimed to put Canadian universities in a disadvantageous position include:

1. shrinking revenues
2. operational inflexibility due to commitments to undergraduates, tenured staff and established areas of interest, as opposed to orienting research toward the needs and interests of industry
3. constraints of federal-provincial financing arrangements.[55]

Despite these stated problems, many Canadian provinces have already developed or are proceeding with the development of innovation centres, in some cases with funding from other Federal government programs. The basic concepts vary from province to province as does the extent of government, university and private sector participation. Some innovation centres, for example, are more specialized technology centres in the areas of microelectronics, robotics or computer aided design. In 1981, Nova Scotia established the 'Applied Microelectronics Institute' in cooperation with Dalhousie University, the Technical University of Nova Scotia and the provincially funded Nova Scotia Research Foundation. One spin-off company has since been created and the Institute is developing products for seven companies in Nova Scotia and two outside the province.[56] In Quebec, the small University of Sherbrooke founded the 'Industrial Microelectronics Centre' in 1982. One spin-off company, Micrologic Inc., has already been created. [57] A network of innovation centres is being established across Ontario with over $100 million in funding from the province's Board of Industrial Leadership and Development (BILD). BILD implements the province's high technology initiatives as specified by a broad management strategy.[58] In addition, the development of six specialized innovation centres has become a core component of Ontario's recently introduced Science and Technology Policy.

These examples, as well as the many other projects under development in other provinces, demonstrate that the innovation centre has been adopted as a major policy instrument for establishing a science a technology infrastructure necessary for creating and attracting high technology firms. Although initially part of a federal experiment, provincial governments and universities are now taking a lead role in establishing innovation centres across Canada.

Information Banks

It is becoming increasingly evident that information flow has a significant impact on the development of high technology firms. Small to medium-sized high technology companies require much technical and market data throughout the innovation process, as well as information concerning the local availability of venture capital, skilled labour and advisory assistance in upgrading management skills. External support in these areas is critical because most small to medium-sized high technology companies do not have the capacity to screen new information, given the large variety of goods produced and technologies utilized by small firms.[59] In addition, many firms lack a well-developed marketing function necessary to identify opportunities for their products and to monitor the competition. Ewers and Wettman (1980) and Thwaites (1983) suggest that public assistance in the form of 'information banks'[60] can strengthen information linkages, which may help firms to successfully introduce their products outside local markets and more quickly adopt innovations developed elsewhere.[61] Moreoever, information banks may increase awareness and interaction among locally-based firms seeking information about business activities. Bollinger et al. demonstrated the importance of information support systems citing a study of high technology firms in the Netherlands which found that many companies actively sought technical and market information from contacts in the United States or Japan while remaining unaware of complementary firms located in the same general area and in some cases, the same industrial park.[62]

Information banks have not been readily established in Canada, perhaps because they overlap with local economic development initiatives. It may also stem from a lack of knowledge of high technology activity at the national and provincial levels, as well as in other countries.

The lack of, or inability to establish a comprehensive information base represents a major obstacle to preparing a high technology strategy, as was noted by several State governments in the United States.[63] In Canada, the Federal government has recently recognized the importance of making information resources available to high technology firms and for improving the general climate for high technology development. The National Research Council, Ministry of State for Science and Technology, Department of Regional Industrial Expansion and the Science Council of Canada have embarked on a joint program to improve the gathering, analysis and dissemination of technological information. To further strengthen this program the Federal Technology Task Force a recommended that the Federal government monitor world technologies, making information available for provincial governments to determine how new technologies would affect industries in their provinces.[64]

Patent Laws

Bollinger et al. note that patent laws can stimulate the creation and development of high technology firms by providing protection to the inventor and assisting efforts to attract potential investors. However, it is further argued that patent laws can discourage spin-offs because employers retain the rights to any invention developed by their employees.[65]. Schott maintains that the role patents play in encouraging innovation is difficult to assess because they are taken out for a variety of purposes, usually to block competitors and because patent laws vary from country to country. It is also recognized that not all patented inventions become successful commercial innovations, although Canadian Patents and Development Ltd., a Federal Crown corporation, maintains an inventory of inventions which are available for license. Therefore, the number of patent filings represents a measure of inventor output as opposed to an innovation stimulant.[66] Nevertheless, some countries like West Germany are experimenting with new patent laws designed to encourage spin-off firms by allowing employees to exploit inventions not pursued by their employers.[67] Although the new laws have contributed to the development of a few new technology firms, it can be generally concluded

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that patent laws play a secondary role in stimulating high technology development.

Public Venture Capital Funds

High technology firms are capital intensive, requiring large amounts of seed capital during the early and risky stages of development. In addition, extensive funding is required for on-going R&D programs. In the United States, entrepreneurs have benefited from a wide range of financing opportunities from both private and institutional investors willing to take speculative risks. The existence of two national and several regional stock exchanges, as well as numerous investment houses which underwrite new share issues, have also contributed to new firm development. To a lesser degree the circumstances in Canada are similar, although it is generally believed that Canadians and their banking system are much more conservative investors than their American neighbours. Moreover, it has already been demonstrated that the Federal government will not lend financial assistance to new technology firms which lack an established track record.[68]

It has been suggested that entrepreneurs in European countries such as Britain, the Netherlands and West Germany do not have the financing options found in North America, perhaps because investors in these countries are more conservative. As a result, many European investors rely on their personal savings for the much needed initial injection of capital. Although Oakey, in his study of high technology firms in the United States and Britain found that 62% of all firms surveyed relied on the personal savings of the founder, venture capital was found to be a significant source of funding for American start-ups, as compared to Britain where venture capital is virtually non-existent.[69]

In an attempt to encourage new firm development, many Western European countries have introduced government sponsored venture capital funds. For example, in 1975 the West German government established the "Deutsche Waginisfinanzieruhgsgeschaft" (The German Venture Financing Company), which invests in the equity of small, innovative firms requiring the necessary startup capital. Unlike most private venture capitalists, this public venture capital fund does not seek controlling interest in the firms in which it invests, allowing the founding entrepreneurs to manage their own operations."[70]

The rising cost of capital coupled with the increased economic uncertainty and poor equity markets during the early 1980's, has resulted in the introduction of public venture capital funds in North America. In the United States, several state governments and their business communities have recently established public venture capital funds for assisting high technology development. Many of these funds have "explicit geographic requirements"[71] to ensure in-state development and prevent leakages to well-known high technology states like California and Massachusetts. In addition, many universities have entered into venture capital partnerships, making them eligible for royalties from successful innovations.[72]

In Canada, the "Senate Committee Report On Science and Technology Policy" published in 1972 recommended the establishment of a public venture capital agency to support small to medium-sized high technology firms. However, the lending and investing institution, to be called the "Canadian Innovation Bank" was never established.[73] Since 1972, only one publicly sponsored venture capital fund has been introduced in this country. Known as Vencap Equities Ltd., this fund was introduced by the Alberta government in 1983. It will be discussed in more detail in the following chapter.

Endnotes: Chapter IV: Technology and Innovation Policies

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24. Ibid., p. 10.

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27. Ibid., pp. 8-9.

28. Litvak and Maule's study conducted in 1971 found that 30% of the firms surveyed could have commercialized their R & D projects without government assistance.

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Thwaites (1983) refers to information banks as 'Technology Change Centres'. He recommends that they be established in Britain, particularly in disadvantaged regions. Proposed functions are very similar to those discussed by Ewers and Wettman.

60. Ewers and Wettman, op. cit., p. 177.

61. Bollinger et al., op. cit., p. 8.

62. Congress of the United States Office of Technology Assessment, op. cit., p. 20.

63. Chevreau (July 24, 1984), op. cit., p. T7.

64. Bollinger et al., op. cit., p. 12.

65. Schott, op. cit., pp. 18-19.

66. Bollinger et al., op. cit., p. 12.

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68. Oakey (1983), op. cit., pp. 24-25.

69. Bollinger et al., op. cit., p. 12.

70. Congress of the United States Office of Technology Assessment, op. cit., p. 6.

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V. Provincial Government Programs & Policies for High Technology Development in Alberta

A. Introduction

Payne (1983) identifies Alberta as "one of Canada's most aggressive provinces in the high technology game,"[1] due to the Conservative government's commitment to diversify the economy. In recent years, the provincial government has introduced several programs designed to develop high technology and scientific expertise, but the long awaited "Proposals for an Industrial & Science Strategy for Albertans 1985-1990" White Paper and "Science & Technology Development in Alberta" A Discussion paper," were not released for public input until mid-1984. The purpose of this chapter is to provide a review of existing programs and draft policies which address how the Alberta government intends to establish a high technology community in this province.

B. Existing High Technology Programs

Several government departments and agencies are involved in various programs designed to encourage the development of high technology industries in Alberta. These organizations include:

a. Alberta Department of Economic Development (Industrial Development Branch)

b. Alberta Research Council (ARC)

c. Alberta Oil Sands Technology & Research Authority (AOSTRA)

d. Alberta Heritage Foundation for Medical Research

e. Alberta Heritage Fund Farming for the Future Program

f. Vencap Equities Ltd. (public sponsored venture capital fund)

g. Alberta Department of Tourism & Small Business (Small Business Equity Corporations

Program)

Alberta Department of Economic Development

The Alberta Department of Economic Development provided the necessary background research for the preparation of the "Proposals for an Industrial & Science Strategy for Albertans 1985-1990" White Paper and the "Science & Technology Development: A Discussion Paper". The first major study completed in 1983 inventoried the number of companies carrying out research and development and the type of research being conducted. A subsequent survey assessing the data processing community was tendered to consultants. Data centres, companies with in-house data processing sections and software firms were inventoried to provide information concerning the type of equipment used, the number of personnel employed and projected growth patterns during the 1980's. In addition, on-going studies outlining opportunities in computer aided design and manufacturing (CAD/CAM), oilfield equipment manufacturing and plastics development are being undertaken. Although many of the high technology firms established in Alberta are related to the energy and agricultural sectors, it is estimated that approximately 300 electronics firms are located in the province.[2]

In addition to these research functions, Alberta Economic Development administers the Product Development Program (PDP). This program provides financial assistance to Alberta-based firms for product and process design and market analysis. Up to 75% of eligible costs to a maximum of $30,000 in funding assistance is available.[3] In March 1985, the incumbent Economic Development Minister announced the creation of the 'Export Services Support Program'. The program is designed to encourage Alberta businesses to seek out export opportunities for goods, services and technical expertise by providing financial assistance for legal, travel and consulting costs.[4] It should be noted however, that these programs are available to all businesses in Alberta and are not specifically targeted for high technology firms. In February 1986, however, the new Department of Technology, Research, and Telecommunications was announced following a reorganization of the Cabinet by Premier

Getty. High technology will have a higher profile in the present Government.

Alberta Research Council

The Alberta Research Council was established by the provincial government in 1921. Operations are directed by a fifteen-member Board comprised of representatives from universities, government and industry. Although the Research Council has traditionally focused its efforts on resources and agricultural research, an Office of Science and Technology was recently established to address high technology research outside these areas and to provide support and information services.

The Alberta Research Council provides joint venture R&D funding for small high technology firms in need of industrial engineering assistance. A maximum of $500,000 per year is available for each approved project over a four year period, with option for renewal. Commerical innovations resulting from this program are jointly licensed by the Alberta Research Council and the innovating firm. Research projects must fall into one of three categories: man/computer/machine interface, biotechnology or chemical catalysis. Other areas of current research activity sponsored by this agency are summarized as follows:

a. Oil Sands and heavy oil research
b. Coal liquefaction research
c. Mineral resources and hydrogeological research
d. Weather and atmospheric research
e. Microelectronics research
f. Agricultural research

With respect to local high technology initiatives, the Alberta Research Council provides the locational focus for prospective high technology firms at Edmonton's Research and Development Park. The Research Council owns an adjoining parcel of land and is constructing a 295,000 square foot research facility on the site. Future neighbouring park tenants will have access to the Research Council's technical information services, professional and technical staff and laboratory facilities.

Alberta Oil Sands Technology & Research Authority (AOSTRA)

The Alberta Oil Sands Technology & Research Authority was established by the provincial government in 1974. Funding is provided to private sector research groups, universities and the Alberta Research Council for developing new recovery techniques and petroleum processing from oil sands and heavy oil deposits, and enhanced recovery from conventional producing fields. In excess of $418 million has been spent on research in these areas to date.[5]

Alberta Heritage Foundation for Medical Research

The provincial government has injected $300 million from the Heritage Savings Trust Fund into clinical and cancer research. Payne claims it is the intent of the government to make the province the "Houston of the North"[6] by constructing advanced medical research facilities necessary for luring a 'critical mass' of renowned medical research specialists. It is anticipated that opportunities for marketing innovative medical products will result in the establishment of a viable health products industry which will serve both national and international markets.

Alberta Heritage Fund Farming for the Future Program

The Farming for the Future program is administered by the Agricultural Research Council of Alberta and financed by the Heritage Savings Trust Fund. First introduced in 1979, the program is a public investment vehicle "designed to improve both net farm income and the long-term viability of Alberta's agricultural industry".[7] Total funding for the 1983-84 fiscal year was $7 million.[8] Originally, the program provided both private and public sector research scientists with funding for projects for the advancement of agricultural technology. However, in 1982 it was broadened to include an "On-Farm Demonstration" program for accelerating the transfer of new technology to producing farms and a "Graduate Student Research Support" program, which provides financial grants to students undertaking meaningful agricultural research.

Vencap Equities Ltd.

Vencap Equities Ltd., a venture capital firm, was sponsored by the provincial government. Although the company raised $44 million from the sale of convertible debentures and common shares to the public in 1983, the debentures and accrued interest are guaranteed by the Alberta government. In addition, Vencap is backed by a $200 million loan package under highly favourable terms from the Heritage Savings Trust Fund.

Vencap's mandate is to expand the province's industrial base by assisting medium-sized companies which have already developed new products, but lack the funds to produce and market them. Investments in the $1-10 million range are made on an equity participation basis, with the shares eventually being repurchased by the innovating firm once it has been successfully established.[9] Vencap is precluded from investing in the oil and gas sector, real estate, nuclear power projects, mutual funds and water diversion projects.

Since its inception, Vencap has been cautious, injecting investment funds into only three Alberta-based firms. However, it has also recently successful in luring an Ottawa-based high technology service firms to Calgary. Synerlogic Inc. is a four year old software service firm with annual sales of approximately $8 million.[10] Although it had been considering relocating in two other Canadian cities, the equity funding from Vencap was the deciding factor behind the move to Alberta.[11] Although venture capital funds are not generally used to attract established firms from other areas, Vencap is a corporate entity intent on making a profit and creating jobs. Assisting companies based elsewhere to expand or relocate inside Alberta will help it to achieve these goals. With approximately $240 million in investment capital available, Vencap could emerge as an influential participant in the province's efforts to establish high technology industries.

Alberta Tourism & Small Business: Small Business Equity Corporations Program

The Small Business Equity Corporations Program was introduced by Alberta Tourism and Small business in mid-1984. Adapted from successful programs previously initiated in Ontario, Great Britain and the United States, it is essentially a venture capital program designed to encourage new equity investment into many smaller businesses requiring start-up capital, funds or R&D programs, debt rescheduling or capital for expansion/acquisitions.

Investors or existing corporations with a minimum of $100,000 are encouraged to form an investment company called a Small Business Equity Corporation (SBEC). Once the SBEC is registered with Alberta Tourism and Small Business, 30% of the equity capital is placed in a trust fund held in the name of the SBEC and the Crown. A grant equal to 30% of the original investment is then paid to the investors and a 30% tax credit is provided to investing corporations. The trust fund acts as collateral for the Crown until such time as investments in one or more small firms are made. Investors cannot hold more than 49% of the voting shares of small firms and 70% of the investment funds must be allocated after the second year of existence. An eligible small business receiving funds cannot be involved in oil and gas exploration, real estate or money lending activities. It must also be a Canadian controlled company with less than 100 employees, pay at least 75% of its wages and salaries in Alberta and remain at arm's length from the SBEC and its shareholders.[12]

The Alberta government originally allocated $15 million to this program which was scheduled to operate for a period of four years. However, the program was over-subscribed with all funds expended after only six months.[13] A total of 142 firms received funding.[14] In order to continue the program, Alberta Tourism and Small Business has proposed an amendment to the Small Business Equity corporations Act and requested an additional $35 million in funding.[15]

C. Science & Technology Development in Alberta: A Discussion Paper

Science & Technology Development in Alberta: A Discussion Paper" serves two vital purposes. First, it is a background statement which addresses the importance of science and technology development and the role it should play in the provincial industrial strategy; and second, it is an implementation document that establishes a framework for supporting and encouraging high technology development in the province. Key policy recommendations in "Proposals for an Industrial and Science Strategy for Albertans 1985-1990" Government White Paper were derived from this study.

The Discussion Paper emphasizes a "dual science strategy"[16] based on the following two objectives:

1. to develop and apply advanced technology for upgrading Alberta's traditional resource industries; and

2. to engage in high technology opportunities that are identified by the private sector and encouraged, where appropriate, by joint industry/government initiatives. These opportunities in some cases will represent spin-offs from activities of the resource industries and in other cases will arise from advances and discoveries made by Alberta's growing population of trained scientists and engineers.[17]

Hence, the Discussion Paper recognizes the importance of focussing on the province's resource strengths, while at the same time maintaining a flexible approach that will also lend encouragement to non-resource based areas 'where appropriate'. The second objective suggests a 'picking the winners' strategy, although potential areas for diversification are not identified. The Discussion Paper does, however, propose a framework "for determining priorities in research and science and for allocating funds for these activities."[18] Recommendations are summarized as follows:

1. Establishment of a Technology Development Authority Board to oversee and co-ordinate all provincial government research and technology development activities in the province (excluding the universities, AOSTRA and the Alberta Heritage Foundation for Medical Research.)

   The Board would perform a broad range of administrative and operational functions for implementing high technology development policies, and would advise the government on all aspects of science and technology policy, development priorities, funding and the monitoring of on-going programs.

2. The establishment of an 'Alberta Innovation Centre' to be aligned with the Alberta Research Council.

   The purpose of the innovation centre is to provide support to inprovince entrepreneurs, Alberta companies developing high technology products and services and private sector and government high technology projects. In addition, the innovation centre will serve to attract out-of-province high technology companies.

The Discussion Paper was released prior to the "Proposals for an Industrial & Science Strategy for Albertans 1985-1990 Government White Paper to encourage discussion on the current technology issues facing the province.

D. Proposals for an Industrial & Science Strategy for Albertans 1985-1990. (Alberta Government White Paper)

The previous Conservative provincial government stressed the importance of diversifying Alberta's economy as early as 1974. Former Premier Peter Lougheed identified the need for a provincial industrial strategy in a public address on September 6, 1974 and confirmed his government's commitment to it in the Legislature on October 23, 1974.[19] However, the need for preparing and implementing a formal published industrial strategy was impaired by a prosperous and growing economy buoyed by rapidly rising oil and gas prices during the latter half of the 1970's. A strong economic growth for the province throughout the 1980's was forecast primarily as a result of further projected increases in petroleum prices. The abrupt downturn of world oil and gas prices coupled with the deepest recession since the 'Great Depression' placed a renewed urgency for the preparation and implementation of an industrial strategy.

"Proposals for an Industrial and Science Strategy for Albertans 1985-1990 is a government White paper "intended primarily for industrial activity and encouragement of the scientific community ....."[20] Thus, it is based on the premise that science and technology development are vital to Alberta's economic viability. The White Paper was released for public input during July, 1984.

The strategy outlines five major goals, which are listed as follows:

1. Economic diversification
2. Balanced economic growth
3. A strong private sector
4. A skilled work force
5. A competitive economy

These goal statements are supported by a series of 'draft policies'. The White Paper addresses High Technology and Research as a "potential new opportunity"[21] for broadening the province's economic base. In fact, high technology development represents a fundamental component of the strategy's thrust. While the White Paper confirms the importance of new technologies in strengthening and expanding the petroleum and agricultural sectors, it suggests that "a solid base has been established" [22] for developing new industrial sectors that may "accelerate the career opportunities for Albertans".[23] Fibre optics, integrated circuits, software development and marketing and biotechnology products represent several examples of innovative technologies identified as being developed in the province, and the White Paper concludes that "Alberta has the potential for a fair share of winners". [24] The 'winners' are expected to evolve from Alberta's "impressive core of entrepreneurs supported by skilled technicians, managers and craftsmen, all backed by outstanding educational and training institutions".[25] This statement is very bold considering Steed identified only thirty 'threshold firms' scattered among all the Prairie provinces in the late 1970's.[26]

With respect to the role played by academic institutions, the White Paper states that "the private sector gives considerable weight in plant location decisions to the proximity of world class universities".[27] In addition, "publicly funded research centres are based in industrial parks near universities to complement further research orientation of these businesses".[28] These conclusions are, perhaps, based on the success achieved by the three prominent American research park examples. Despite the stated emphasis on the necessity for close association with a 'world class university', recent high technology literature does not give similar weight to this location determinant. Instead, the evidence suggests that any university exhibiting strength in certain academic areas (most notably business and electrical engineering), thereby providing the necessary pool of skilled labour meets the requirements of most high technology firms. The University of Alberta, for example, with its strong electrical engineering department and emerging business administration/public management programs meets this standard. Existing and proposed Alberta Government programs have disregarded, to some extent, the university element in their encouragement of high technology development and have instead focused more on the Alberta Research Council as a substitute for the stated "world class university" requirement. For example, the Research and Development Parks being developed in Edmonton and Calgary have not established close linkages with their respective university campuses. At both sites the Alberta Research Council serves as the lead agency in providing research facilities and services to prospective firms that may locate in these parks. The Alberta Research Council has also been identified as the lead research agency for the proposed 'Innovation Centre' and recently developed 'Electronics Test Centre', which represent core components of the science and technology policy. This role may be questionable given the achievements of university-based innovation centres in the United States and more recently at the University of Waterloo in Ontario. While it is accepted that academic institutions can play an important role in fostering high technology development, the White Paper does not offer any policy direction for encouraging greater interaction between Alberta's universities and private industry. New directions for education are suggested to "foster ideas of risk taking, innovation and the pursuit of excellence".[39] However, none of the recommendations stress entrepreneurial training that combines the classroom with real business world experience. It should be noted, however, that the University of Alberta's Department of Electrical Engineering and the Faculty of Business have a number of innovative programs which the government has supported strongly and which should contribute to increased linkages between government, industry and the university.

Several additional policy 'options' for the development of high technology industries in Alberta are identified by the White Paper and all have been addressed by the seven existing programs discussed at the beginning of this chapter. All programs were implemented by the Alberta government prior to the release of this document.

E. Discussion

Over the past decade, the Government of Alberta has introduced a variety of programs to promote economic development in general and more recently to attempt to generate high technology development. However, it has long been demonstrated that a provincial industrial strategy is required to steer a course for the province's future and achieve the overall goal of diversifying Alberta's economic base. An industrial strategy serves several functions:

1. It enables business and government officials to have a clear understanding of what the goals of industrial policy are.
2. It targets industrial groups that are most likely to succeed, thereby contributing to overall economic growth
3. It enables government departments to concentrate their efforts on assisting business through a co-operative institutional framework that minimizes duplication and conflicting programs.
4. It enables government to support projects that meet an identifiable need and, therefore, have a substantial chance of success.

The Government of Alberta's proposed industrial strategy is entitled "Proposals for an Industrial and Science Strategy for Albertans 1985-1990". (White Paper). The release of the White Paper for public input after all existing programs were implemented suggests that government officials did not have a clear understanding of the goals of industrial policy in Alberta. While it may be premature to assess the effectiveness of many existing programs, the White Paper merely justifies these programs without reviewing them in the context of an overall industrial strategy. For example, Vencap Equities Ltd. has been criticized by small firms requiring less funding than the minimum requirements set by the venture capital firm. The

Small Business Equity Corporations Program was eventually introduced to fill that need. However, this program is designed to assist small business in general as opposed to targeting firms in areas of emerging technology. More importantly, the White Paper has failed to qualify existing and potential areas of strength other than the petroleum and agricultural sectors, which represent logical extensions of the province's resource base. These deficiencies demonstrate the need for a comprehensive survey of high technology firms in Alberta to provide a greater understanding of the existing base and potential for high technology development, as well as a preliminary indication of the effectiveness of existing government programs. The following chapter condenses the findings of the literature review provided in Chapters 2-5 and distills from it a series of research hypotheses to be addressed by a survey of high technology firms in Alberta.

Endnotes: Chapter V: Provincial Government Programs and Policies For High Technology Development in Alberta

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2. J.P. Cowan, "Alberta Industry Seeks Competitive Edge", The Globe and Mail. (Toronto), Friday, May 20, 1983, p. B14.

3. Price, Waterhouse Associates, op. cit., pp. 18-19.

4. Price, "Export Drive to Cost Alberta 17 Million", Edmonton Journal. (Edmonton), Thursday, March 28, 1985, p. D3.

5. Edmonton Economic Development Authority, Edmonton High Technology Development Report. 1983, p. 39.

6. Payne, op. cit., p. 35.

7. Agricultural Research Council of Alberta, Farming for the Future: Progress Report 1983. Annual Report, 1983, p. 1.

8. Ibid.

9. Cowan, op. cit., p. B14.

10. John DeMont, "Alberta's Vencap Can Dangle a Pretty Big Carrot", The Financial Post. (Toronto), September, 1984 (no page reference).

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12. Alberta Department of Tourism and Small Business, Small Business Equity Corporation Program. Information booklet, 1984.

    Lois Bridges, "Small Businesses Welcome S.B.E.C. Boost", Small Business Quarterly.

Alberta Department of Tourism and Small Business, Vol. 3, No. 4, 1984, pp. 5-7.

13. Robert Sibley, "$35 Million Sought for Small Business", Edmonton Journal. (Edmonton), Wednesday, March 27, 1985, p. H4.

14. Ibid.

15. Ibid.

16. Government of Alberta, Science and Technology Development in Alberta: A Discussion Paper. March, 1984, p. 18.

17. Ibid., p. 18.

18. Ibid., p. 10.

19. Government of Alberta, Proposals for an Industrial and Science Strategy for Albertans 1985-1990, (White Paper), July, 1984, p. 3.

20. Ibid., p. 3.

21. Ibid., Section E, p. 44.

22. Ibid., p. 44.

23. Ibid., p. 44.

24. Ibid., p. 44.

25. Ibid., p. 55.

26. Steed, op. cit., p. 110.

27. Government of Alberta (White Paper), op cit., p. 35.

28. Ibid., p. 44.

29. Ibid., p. 67.

VI. Literature Review Summary & Identification of Research Hypotheses

The public release of the Alberta Government White Paper "Proposals for an Industrial and Science Strategy for Albertans 1985-1990", confirms the province's intent to establish high technology industries as an economic diversification strategy. Although the White Paper claims a strong base for high technology development is already present within the province, very little is actually known about existing high technology firms. Chapters two to four, which provided a review and analysis of high technology development elsewhere, raise several questions which need to be addressed in the Alberta context. The following summary identifies four important areas of research, from which more specific questions were developed as part of a survey of high technology firms in Alberta.

A. Categorization of High Technology Firms in Alberta

The literature review suggests that high technology sector is broadly based and includes a wide array of industrial groups. These groups include small to medium-sized independent technology firms which are founded by individuals or groups of entrepreneurs, as well as subsidiaries of larger corporations, both Canadian and foreign-owned. Information concerning the type and ownership of high technology firms being established in Alberta is lacking, and requires identification. This information is vital for determining the overall base and potential for high technology development in the province and will further identify the level of entrepreneurial activity in Alberta versus the expansion of high technology subisidiaries of parent firms headquartered elsewhere.

Research Hypotheses

1.1 That high technology activity in Alberta is associated predominantly with resource-based and service-oriented companies, rather than with the stereo typical computer, semi-conductor and electronics firms.

1.2 That most medium-sized and large high technology firms in Alberta are subsidiaries of foreign and Canadian firms with headquarters outside Alberta as opposed to independent Alberta-owned companies which are small in size.

1.3 That most independent firms started by entrepreneurs are young in age, that is, less than five years old as opposed to most subsidiary firms which were established more than ten years ago. In addition, most independents have not established subsidiaries elsewhere.

B. Performance of High Technology Firms

It is generally accepted that high technology firms are highly competitive and innovative. They have exhibited strong growth rates, generated new, stable, well-paying professional and technical employment and are successful in export markets. Moreover, these trends tend to be more pronounced in small to medium-sized independent firms founded by technological entrepreneurs as opposed to larger foreign-controlled subsidiaries. These generalizations, in many cases, focus on a select group of industries which may not be representative of the high technology sector as a whole. The literature review has demonstrated a wide variety of experiences in the performance and progress of high technology industries, suggesting that it is dangerous to prejudge the group as a result of specific sectors which have gained prominence from remarkable successes. It has been further suggested that R&D expenditures contribute to the overall success of high technology firms. While it is not argued that R&D is fundamental to the firm's strategy of being innovative and competitive, successful high technology firms have struck a balance between R&D, marketing and production. This balance has been achieved as a result of strong management and organizational skills on the part of founding entrepreneurs. Analysis of independent high technology firm failures in this country indicates that the Canadian entrepreneurs who founded them were lacking these important management and organizational skills.

At present, very little is known about the performance of high technology firms in Alberta. The questionnaire survey will address the areas of growth rates, employment growth, markets, competition, R&D activity and entrepreneurship. Analysis of the results will provide valuable information concerning the strength and viability of high technology firms in this province, thus allowing a more accurate assessment of its potential role for economic diversification and decentralization in Alberta.

Research Hypotheses

2.1 That gross revenue and net profit performance among high technology firms is greater in independent firms than Canadian and foreign controlled subsidiaries

2.2 That high technology sectors exhibit a wide variety of experiences in gross revenue and net profit growth

2.3 That high technology firms directly associated with Alberta's resource industries have been generally more successful than others.

2.4 That most Canadian and Foreign controlled subsidiaries carry out their R&D programs outside Alberta.

2.5 That most small high technology firms conduct part-time R&D programs compared to medium-sized and large high technology firms which carry out full-time R&D, and that most high technology firms prepare an R&D budget.

2.6 That investment in R&D is focused on adaptations of existing products and processes rather than new product/process development.

2.7 That R&D programs carried out by independent high technology firms are primarily contracted to external groups and agencies.

2.8 That R&D programs carried out by independent high technology firms are funded primarily by federal and provincial government assistance programs

2.9 That high technology firms have not created much direct employment in Alberta.

2.10 That new high technology employment created has been largely in low skilled, low paying non-professional positions as opposed to highly skilled, high paying professional and technical employment.

2.11 That high technology firms generate most of their sales in Alberta before achieving significant export sales to the United States and other foreign markets.

2.12 That independent high technology firms require or are receiving government assistance for identifying and penetrating new markets.

2.13 That independent high technology firms are entering areas of intense competition rather than identifying a market niche where a headstart could be developed.

2.14 That independent high technology firms were founded by technological entrepreneurs that recieved their academic training and experience outside Alberta.

2.15 That most high technology entrepreneurs rely on their personal savings as a source of start-up capital rather than external financial sources.

C. Locational Preference of High Technology Firms

The success of the three major research parks in the United States: 'Silicon Valley', 'Route 128' and 'Research Triangle', gave strong support to the view that high technology industries require industrial park-like facilities to carry out their operations. Several regions in the United States and Canada, including Alberta, have introduced research parks based on these examples in an attempt to spur high technology development. Many of these parks failed or achieved extremely low occupancy rates, demonstrating that there will be very few 'Silicon Valleys'. and that the research park is only one method for establishing high technology industries. Subsequent review and analysis of locational survey literature has revealed diverse locational behaviour among high technology groups. However, labour skills and availability, labour cost, proximity to a university and proximity to airports have emerged as important location factors.

Research Hypotheses

3.1 That high technology firms prefer non-research park locations

3.2 That labour skills and availability are more important location influences than proximity to a university.

3.3 That the cost of labour is an important locational influence.

3.4 That tax climate is an important locational influence.

3.5 That the home of the founding entrepreneur often explains location.

3.6 That metropolitan location will be preferred rather than regional cities or small towns because of the availability of services.

D. Government Support Programs

In their attempts to support high technology development, the governments of numerous western developed countries have initiated or experimented with a variety of policy mechanisms. Encouragement of R&D by providing direct and indirect government subsidies is, perhaps, the most common form of government support designed to stimulate the innovation process. In Canada, the Federal government administers R&D subsidy programs at a cost of $500 million annually. Federal government R&D support may be critical to many small to medium-sized high technology firms because they lack the personnel and financial resources to conduct planned programs. Therefore, it is essential to address the importance of government R&D support programs to high technology firms in Alberta.

During the past decade, the provincial government of Alberta has introduced several programs designed to support high technology development. These programs were subsequently followed by an Alberta Government White Paper and Discussion Paper which further clarified the government's position on economic growth for the province and reinforced the importance of high technology programs presently in place. However, the effectiveness of existing programs remains unclear and the number of high technology firms that make use of them is uncertain. In addition, it is not known what initiatives high techology firms believe all levels of government should take to support high technology development in the province. Information concerning government support programs is critical at this time in view of the provincial government's planned efforts for establishing a high technology base in Alberta.

Research Hypotheses

4.1 That indepedent high technology firms prefer financial grants to fund R&D programs as opposed to tax incentives.

4.2 That larger subsidiaries prefer tax incentives for R&D funding as opposed to financial grants.

4.3 That provincial government financial assistance has served to attract high technology firms to locate in Alberta

4.4 That provincial government support programs are more important to subsidiary firms than independents.

4.5 That local government high technology programs have not played yet an important role in attracting high technology firms.

E. The Questionnaire & Data Collection Methods

In order to ascertain the broad level of high technology development in Alberta as well as to address the research hypotheses highlighted at the beginning of this chapter, it was decided to prepare and carry out a comprehensive questionnaire survey. Immediately, problems were encountered in establishing a population of high technology firms because of differences in perception of many government departments and agencies as to what was meant by a high technology firm. Although considerable debate has occurred already on this issue, a working definition of high technology in Alberta has not emerged and a provincial directory of high technology firms has never been prepared.

The Alberta Department of Economic Development (High Technology Section) was contacted and a list of firms with research and development capital was provided by it. Based on analysis of product, service and presence of R&D by professional personnel[1] employed outside Alberta Economic Development, it was conluded that this list was incomplete. A comprehensive list of high technology firms located in the Edmonton region was provided by the Edmonton Research & Development Park Authority and the Calgary Economic Development Authority in association with the Calgary Research & Development Park Authority forwarded their recently published directory of high technology firms in the Calgary area. To supplement these sources, the Electronics Directory of Alberta, Nickle's Canadian Oil & Gas Register and an unpublished list of firms engaged in oil sands research prepared by the Alberta Oil Sands Technology Research Authority were scrutinized. It quickly became evident that no one in Alberta had a complete list of high technology firms. While the initial survey population of 360 firms compiled by this author may still be incomplete, it is likely the most up-to-date list of high technology firms in Alberta.

The data were collected from a sample of 339 high technology firms (see below). To help overcome the drawbacks of a mail-out questionnaire survey, personal interviews with executive or management personnel were to be arranged with 50 firms. It was feared that unless contacted personally, corporate executives or management personnel would not be willing to expend time to complete a lengthy questionnaire that asked questions about the nature of their businesses. However, problems were encountered in both contacting corporate personnel and scheduling interviews at a convenient time. In some cases personnel did not have the authority to grant interviews, while others simply did not want to discuss their operations in more detail. One executive declined to participate in this survey because "a number of questions sought answers to highly confidential matters which no company working in a competitive field is likely to make known to others". As a result, only 6 (personal and telephone) interviews were completed. They were included in the results and because they provided additional information and insight, this attempt was not a complete failure. Similar problems were encountered by Peterson (1982) in his survey of manufacturing wholesalers in the Edmonton region. That particular study relied mainly on questionnaires completed and returned through the mail.

Although concern was expressed about having to rely on a questionnaire survey answered and returned via the mail, a pre-test survey of 20 firms found that executive and management personnel were able to complete the questionnaire in approximately twenty minutes. The relatively short completion time for such a comprehensive questionnaire was achieved in part by avoiding lengthy open-ended uestions. Previous research by Matthews (1979) demonstrated the difficulties encountered by Alberta businessmen in answering open-ended questions. Not only did respondents generally avoid them, but the quality of information received was generally poor.[2] The present survey was no different. The few open-ended equestions that required some thought were in many cases left unanswered and generated the poorest quality of information. Although the structure of the questions posed is important in eliciting responses, the willingness of the respondents to supply data varies with the type of information sought. Of particular concern was the section dealing with commercial performance, which examined financial matters often perceived to be confidential by corporate management. Moreover, most firms are private limited companies and do not require public disclosure. Litvak and Maule (1980) found that because many firms were reluctant to disclose financial data, they had to instead rely on approximations obtained from interviews to permit a general overview of business progress.[3] However, their sample was significantly smaller which in most cases, enabled them to conduct in-depth interviews and obtain sufficient data. In an attempt to overcome this problem, it was decided to elicit general financial data in the hope of establishing business trends rather than seek specific financial data, which probably would have been left mostly unanswered.

Finally, to encourage participation in the survey, a formal covering letter which explained the purpose of the study and assured confidentiality of responses was included with each questionnaire distributed.

F. Statistical Procedures

Analysis and interpretation are central steps in the research process. The purpose of analysis is to summarize the collected data in order to provide answers to the research questions derived from the literature review. On the other hand, interpretation determines the implications of the results found within the broader framework of existing knowledge. Two types of statistical analysis were used in this study : descriptive statistics and inferential statistics. Descriptive statistics (measures of central tendency, variability and relationships) were used in summarizing data obtained from this survey. In addition, they were used to summarize and compare results obtained from a post-survey test of 50 non-respondent high technology firms. This post-survey test was conducted to determine representativeness of the questionnaire survey sample. Inferential statistical procedures (chi square and significance) were used to determine whether differences between groups were statistically significant or not, that is, whether it could be concluded that they occurred as a result of something other than chance. In accordance with accepted test procedures, a significance level of .05 (5%) was chosen. This level increases the power of the test and reduces the chance of rejecting the null hypothesis when it may, in fact, be acceptable. If the observed significance level is.05 or less, the hypothesis that the two variables are independent is rejected. The relationship found to exist is correct at least 9.5 times out of 10 (95%).

Chi square (test of independence) and observed significance levels (strength of association between two variables) were calculated and printed out by the SPSSX computer program. However, in many cases data had to be re-grouped in order to permit chi square analysis. Chi square calculations were subsequently computed by hand and compared with a chi square table using the .05 significance level. These statistical procedures are further explained in Elifson et al. (1982) and Norusis' (1983) Statistical Package for the Social Sciences (SPSSX) for the computer operation of these techniques.

G. Survey Results

The total population of high technology firms in Alberta was identified initially as 360 firms. Following a successful pre-test of 20 questionnaires, which were delivered by hand and subsequently retrieved, a 100% mailed questionnaire survey was conducted. Only 3 firms could not be located, confirming the accuracy of the mailing list. An additional 18 firms were found to be discontinued after verification was made with the Alberta Department of Consumer and

Corporate Affairs. These 21 companies were deducted from the total population, reducing it to 339 firms. There were 125 returns for an overall response rate of 36.8% Of these, 116 questionnaires (including interviews) were usable for a survey response rate of 34.2%. In terms of company officers, the Chief Executive Officer completed 44%, the Vice-President 18% and Managers 23% of all responses.

Subsequent to the completion and tabulation of data collected from the questionnaire responses, a post-survey of 50 randomly chosen non-respondent high technology firms was conducted to test representativeness of the sample. Data concerning two dependent variables, firm ownership and full-time employment size, were collected, tabulated and compared with the initial survey results. These data are shown in Table 6.1

Althought the non-respondent survey found 15.1% more independent Alberta-owned firms than the inital questionnaire survey, it confirmed that this group comprises the largest proportion of high technology firms in the province. Only 8.1% fewer Canadian subsidiaries and 4.4% less foreign subsidiaries were found by the test survey. Based on these results, the respondent sample can be accepted as representative of the total population by firm ownership. With respect to full-time employment size, the mean number of employees working for independent high technology firms was 30 for the non-respondent survey compared to 31 for the questionnaire survey. While the accuracy of these results confirms a representative sample of independent high technology firms, significant mean employment discrepancies were observed in both the Canadian and foreign subsidiary firm groups. Other measures of central tendency (median, mode) were not useful tests because of the relatively small number of responses received from these two groups in both surveys. However, examination of the range of total full-time employees in the questionnaire survey revealed a wide range of firm size by employment. The smallest Canadian subsidiary had 4 full-time employees compared to 4,600 in the largest, while the smallest and largest foreign subsidiaries had 7 and 3,300 employees respectively. More importantly, in both subsidiary groups the majority of respondent firms were categorized as small in size, that is, having less than 100 full-time employees. The same

TABLE 6.1

COMPARISON BETWEEN ALBERTA HIGH TECHNOLOGY FIRM QUESTIONNAIRE SURVEY AND POST-SURVEY OF NON-RESPONDENT FIRMS

1. Firm Ownership

Firm Ownership	Questionnaire Survey # Responses	Questionnaire Survey %	Non-Respondent Survey # Responses	Non-Respondent Survey %
Independents	73	62.9	39	78.0
Canadian Subsidiaries	21	18.1	5	10.0
Foreign Subsidiaries	19	16.4	6	12.0
Other	3	2.6	0	0.0
	116	100.0	50	100.0

2. Employment Size (Mean number of full-time employees)

	Questionnaire Survey	Non-Respondent Survey
Independents	31	30
Canadian Subsidiaries	542	39
Foreign Subsidiaries	380	186

3. Cross Tabulation of Firm Ownership by Employment Size

Firm Ownership	Questionnaire Survey Employment Size <100	Questionnaire Survey Employment Size 100-999	Questionnaire Survey Employment Size >1000	Questionnaire Survey Total	Non-Respondent Survey Employment Size <100	Non-Respondent Survey Employment Size 100-999	Non-Respondent Survey Employment Size >1000	Non-Respondent Survey Total
Independents	58	5	0	63	36	3	0	39
Canadian Subsidiaries	7	6	2	15	4	1	0	5
Foreign Subsidiaries	9	6	1	16	5	1	0	6
	74	17	3	94	45	5	0	50

pattern was observed for the post-survey of non-respondent firms (Refer to Table 6.1). This trend suggests that the large mean number of employees calculated for both subsidiary groups in the questionnaire survey was distorted by those large firms with several thousands employees. Furthermore, this imbalance accounts for the wide differences in mean full-time employment found in the non-respondent survey sample of Canadian and foreign subsidiary firms. Because the total population was found to contain relativley small numbers of Canadian and foreign subsidiary firms, very small and very large subsidiaries with extreme variation in employment size appeared in the questionnaire respondents. These results skewed any tests for representativeness by employment size in the subsidiary firm categories.

Chapter VI: Literature Review Summary and Identfication of Research Hypotheses

1. Assistance in identifying high technology firms was provided by Glenn Mitchell, General Manager of the Edmonton Research and Development Park Authority and Michael Werb of the Industrial and Engineering Branch, Alberta Research Council.,

2. Matthews op. cit.. pp. 50-52.

3. Litvak and Maule (1980) op. cit.., p. 78

VII. High Technology Questionnaire Survey: Results & Analysis

A. Introduction

This chapter analyses and summarizes the results of the high technology questionnaire survey conducted during the summer of 1985. The questionnaire was divided into the four sections used to highlight the research questions listed in Chapter 6. The first section deals with the categorization of high technology firms in Alberta. The second assesses the commercial performance of high technology firms. Section three addresses locational behaviour, while the last section evaluates federal and provincial government support programs. Finally, to provide perspective for the results, information from this survey will be compared with the findings of previous studies which present the problems and successes of high technology firms elsewhere.

B. Categorization of High Technology Firms in Alberta

Information about the type, ownership, size and age of high technology firms in Alberta is lacking. This information is vital for determining the overall basis and potential for high technology development in the province. In addition, it will further serve as an indicator as to whether such firms provide a basis for economic diversification or exhibit a dependence on existing resource industries. Finally, it will help to identify the degree of independent entrepreneurial activity compared with subsidiary plant development.

Firm Type

The Standard Industrial Classification (S.I.C.) has long been used as the primary means for categorizing all types of firms. In past studies, it has been successfully used by Steed (1982) for classifying 'threshold firms' in Canada and Glasmeier et al. (1984) for coding high technology firms in the United States.[1] However, some analysts like Browne (1983b) stress that product or service is more important than a set of industries defined by S.I.C. codes. As a result, many studies have been using product or service as a more applicable replacement for

S.I.C. codes. This survey provided a compromise using S.I.C. codes and product or service produced to categorize high technology firms. The results are shown in Tables 7.1 — 7.2.

Research Hypothesis 1.1:

> That high technology in Alberta is associated predominantly with resource-based and service-oriented firms rather than with the stereo typical computer, semi-conductor and electronics manufacturing firms.

Using S.I.C. categories, 28.4% of the respondent firms described their major business activity as 'Services to Business Management' (includes engineering and scientific services), followed by 26.7% in 'Miscellaneous Manufacturing' (includes scientific and professional equipment). 'Communication Industries' (12.1%) ranked next, then 'Electrical Products Industries' (10.3%) and 'Services Incidental to Mining' (8.5%) (includes contract drilling for petroleum). In terms of proportion of sales of their major product or service, 32.7% responded in the computer category, followed by 30% in the electronics and communications category. Consulting services (10.9%) and the petroleum industry (9.1%) were other major areas of product or service activity.

It is clear from the results that firms providing services (38.7) comprise a strong component of high technology development in Alberta. Although a major market for management/consulting service firms exists in the resource industries, the responses suggest that high technology firms were not particularly associated with the resource sector. Main products were strongly in the electronic, communication and computer areas, which are commonly associated with stereo-type high technology firms. Therefore, hypothesis 1.1 cannot be accepted.

Firm Ownership and Size

In this survey firm size was measured by determining the number of full-time employees with each firm. Although this measure is an easily obtainable and acceptable procedure, there is no single and widely agreed upon definition that delineates the upper limit

TABLE 7.1

CATEGORIZATION OF HIGH TECHNOLOGY FIRMS IN ALBERTA BY BUSINESS ACTIVITY

S.I.C. Code (Major Group)	No. of Responses	%
Services to Business Management	33	28.4
Miscellaneous Manufacturing	31	26.7
Communication Industries	14	12.1
Electrical Products Industries	12	10.3
Services Incidental to Mining	10	8.6
Chemical Products Industries	4	3.4
Mineral Fuels	4	3.4
Metal Fabricating Industries	2	1.7
Services Incidental to Agriculture	2	1.7
Experimental & Institutional Farms	1	.9
Petroleum & Coal Products Industries	1	.9
Machinery Industries	1	.9
Transportation Equipment	1	.9
	116	100

TABLE 7.2

CATEGORIZATION OF HIGH TECHNOLOGY FIRMS IN ALBERTA BY MAJOR PRODUCT/SERVICE

Major Product or Service	No. of Responses	%
Computer Firms	36	32.7
Electrical & Communications	33	30.0
Consulting Services	12	10.9
Petroleum Industry	10	9.1
Agricultural	3	2.7
Biomedical	2	1.8
Other	14	12.7
	110	100

of a small firm or the lower limit of a large one. Steed (1982) for example, defined small high technology firms as having less than 100 employees. Oakey (1983a) used 200 full-time employees as his upper range limit for defining small high technology firms. For this study, a small firm was defined as having less than 100 full-time employees; a medium-size firm as having 100-999 full-time employees; and a large firm as having 1,000 or more full-time employees. Firm ownership was assessed first by determining the number of private, public and Crown corporations, followed by categorization into independent Alberta-owned firms, Canadian subsidiaries and foreign subsidiaries.

Research Hypothesis 1.2

> That most medium-size and large high technology firms in Alberta are subsidiaries of Canadian and foreign-owned firms with headquarters outside Alberta as opposed to independent Alberta-owned companies which are small in size.

Private corporations accounted for 73.9% of responding firms, public corporations 20% and Crown corporations 1.7%. Independent firms represented 64.4% of the respondents, followed by Canadian subsidiaries (18.6%) and foreign subsidiaries (16.8%). A statistically significant cross-tabulation showed that 67 of 72 (93%) indepedent firms were private corporations. Most Canadian subsidiaries (52.3%) were also private corporations, but 13 of 19 (68.4%) foreign subsidiaries were publicly traded companies. These results are shown in Tables 7.3-7.5. A cross-tabulation of major product or service provided and firm ownership found that 64.7% of the independents were in the computer, electronics and communication sectors. Only one firm (1.4%) was in the petroleum industry. Similarly, 60.5% of all subsidiary firms were in the computer, electronics and communication sectors, but a substantially higher proportion (21%) were found in the petroleum industry. Tables 7.6-7.7 illustrate firm size in terms of full-time employment. Most high technology firms (76%) were small in size. Medium-sized firms accounted for 19.8% of the responses, while only 4.2% were large firms. The mean number of full-time employees for independents was 31, compared to 542 for Canadian subsidiaries and 380 for foreign subsidiaries. A statistically significant

TABLE 7.3

FIRM TYPE

Type of Firm	No. of Responses	%
Private Corporation	85	73.9
Public Corporation	23	20.0
Crown Corporation	2	1.7
Other	5	4.3
	115	100

TABLE 7.4

FIRM OWNERSHIP

Ownership of Firm	No. of Responses	%
Independent	73	64.6
Canadian Subsidiary	21	18.6
Foreign Subsidiary	19	16.8
	113	100

TABLE 7.5

CROSS-TABULATION OF FIRM TYPE BY FIRM OWNERSHIP

	Independent	Canadian Sub.	Foreign Sub.	Row Total
Private Cororation	68	11	6	85
Public Corporation	4	6	13	23
Other	1	4	0	5
Column Total	73	21	19	113

Chi-square = 51.45971 Critical Chi Square at .05 Significance = 9.49

TABLE 7.6

FIRM SIZE

Employment Size	No. of Responses	%
Small (less than 100 employees)	73	76.0
Medium (100-999 employees)	19	19.8
Large (1,000 or more employees)	4	4.2
	96	100.0

cross-tabulation of firm ownership by size was made with 58 out of 63 (92%) independent firms showing less than 100 employees. There were no independents with 1,000 or more employees. Seven Canadian and 7 foreign subsidiaries had less than 100 employees; 6 Canadian subsidiaries had 100-999 employees with 2 firms above 1,000. Eight foreign subsidiaries had between 100-999 employees with one firm over 1,000 employees.

These data confirm that most medium to large high technology firms are subsidiaries of Canadian and foreign-owned companies headquartered outside the province. In contrast, the majority of small firms are independent-owned Alberta companies. Therefore, hypothesis 1.2 is accepted.

Firm Age

By examining firm age, much can be learned about the historical development of high technology firms. More specifically, an indication as to the degree of high technology development generated prior to and during the recent "boom years" can be determined. In addition, the proportionate rate of firm creation since the economic recession which began in 1981 can be measured.

Research Hypothesis 1.3:

> That most indepedent firms started by entrepreneurs are young in age, that is, less than five years old, as opposed to most subsidiary firms which were established more than ten years ago. In addition, most independents have not established subsidiaries elsewhere.

Most firms (64.6%) were founded more than 6 years ago during the boom period between 1973-1981. However, 35.4% were created during the last five years suggesting that high technology firm development has occurred since the beginning of the last economic recession. In terms of independent firms, 31 were established within the last five years, 19 between six and ten years ago and 22 more than ten years ago. Therefore, most independent firms are not young in age, although they have accounted for 79.4% of all high technology firms created during the last five years. The majority of independent firms were established during the last ten years. In comparison to Canadian and foreign subsidiary firms, it is signficant to note that 26 of 41 (63.4%) subsidiaries were established in Alberta more than ten years ago. Of the foreign subsidiaries, 16 of 19 (84.2%) were established more than ten years ago. No foreign subsidiaries were established also during the last five years. Although most firms (56.5%) had not established subsidiaries, a surprisingly high 43.5% had done so, generally with one subsidiary only. Major locations were Alberta (28.1%), the United States (21.9%) and Eastern Canada (18.8%).

Most indpendent firms were not young in age and the majority of subsidiary firms were found to be greater than ten years old. Finally, as expected, most independents have not established subsidiary firms elsewhere. Therefore, hypothesis 1.3 can only be partially accepted.

Summary

High technology in Alberta is comprised largely of independently-owned private corporations in the computer, electronics and communication and consulting services sectors. They are generally small in size, averaging 31 full-time employees per firm, were established primarily less than ten years ago and are mostly single plant operations in that they have not established subsidiary firms. In contrast, most medium-sized and large high technology firms consist of Canadian and foreign subsidiaries that established their operations in Alberta more than ten years ago. However, the majority of subsidiary firms were also found in the computer, electronics and communication sectors. These findings indicate a trend of firm development not directly linked to the resource sector which suggests that a diversification process is occurring.

C. Commercial Performance of High Technology Firms

In this section the commercial performance of high technology firms is reviewed. Information concerning growth rates, R&D activity, employment growth, markets and competition, and entrepreneurship is necessary for evaluating the strength and viability of high technology firms in this province. By completing this analysis, the potential for the development of high technology industry in Alberta, a periphery region in Canada and North America, could be obtained.

Growth Rates

Growth rates were measured by examining gross revenues for 1983 or the latest fiscal period ending in 1983, trends in gross revenues and net profit for the 5 years prior to the 1983 year end and projected gross revenue and net profit growth (expressed as a percentage) for the two years following 1983. The purpose was to determine the stages of corporate growth and growth trends which could be used to evaluate the general financial health of high technology firms in Alberta. In addition, analysis of growth trends will provide an indication of which industrial groups (if any) are generally more successful.

Research Hypothesis 2.1:

> That gross revenue and net profit performance among high technology firms is greater in independent firms than Canadian and foreign controlled subsidiaries.

Table 7.8 illustrates the total gross revenues generated during 1983. High technology firms which generated gross revenues of less than $1 million accounted for 41.6% of the respondents. Within this group 70.2% had annual revenues of less than $500,000. Revenues between $1-9.99 million accounted for 33.6% of the respondents and 24.8% grossed more than $10 million. A statistically significant cross tabulation of firm ownership by 1983 gross revenues (Table 7.9) was made. Of the independents, 56.9% generated revenues of less than $1 million. However, 38.9% had revenues between $1-9.99 million, while only 4.2% were greater than $10 million. In contrast, 16 of 19 (84.2%) foreign subsidiaries had annual revenues of more than $10 million, while only three firms (15.6%) generated revenues of between $1-9.99 million. There were no foreign subsidiaries with revenues less than $1 million. Similarly, most Canadian subsidiaries (42.1%) had revenues greater than $10 million, but substantially more (26.3%) grossed less than $1 million in 1983. A cross tabulation of firm age by 1983 gross revenues was also found to be statistically significant (Table 7.10). Of the firms which generated more than

TABLE 7.7

CROSS TABULATION OF FIRM SIZE BY FIRM OWNERSHIP

	Independents	Can. Subs.	Foreign Subs.	Row Total
Small (<100 employees)	58	7	7	72
Medium (100-999 employees)	5	6	8	19
Large (>1,000 employees)	0	2	1	3
	63	15	16	94

Chi-Square = 27.91588 Critical Chi-Square at .05 Significance = 9.49

TABLE 7.8

GROSS REVENUES GENERATED (1983)

Value	No. of Responses	%
< $1 Million	47	41.6
$1-9.99 Million	38	33.6
>$10 Million	28	24.8
	113	100.0

TABLE 7.9

CROSS TABULATION OF FIRM OWNERSHIP BY GROSS REVENUES GENERATED (1983)

Firm Ownership	<$1 Million	$1-9.99 Million	>$10 Million	Row Total
Independents	41	28	3	72
Canadian Subsidiaries	5	6	8	19
Foreign Subsidiaries	0	3	16	19
Column Total	46	37	27	110

Chi Square = 86.1 Critical chi square at .05 Significance level = 9.49

TABLE 7.10

CROSS TABULATION OF FIRM AGE BY GROSS REVENUES GENERATED (1983)

Firm Age	<$ 1 Million	$1-9.99 Million	>$10 Million	Row Total
<5 Years	27	10	2	39
6-10 Years	12	9	4	25
>10 Years	8	19	22	49
Columns Total	47	38	28	113

Chi Square = 64.515 Critical chi square at .05 Significance level = 9.49

$10 million in gross revenues during 1983, 22 of 28 (78.6%) were established in Alberta more than 10 years ago. Nineteen of 38 (50%) firms with revenues between $1-9.99 million were also established more than 10 years ago. Most firms with annual revenues of less than $1 million (57.4%) were created primarily during the last five years. Of those firms created during the last five years, 27 of 39 (69.2%) generated gross revenues of less than $1 million. However, 10 of 39 (25.6%) had revenues of between $1-9.99 million and 2 firms indicated revenues in excess of $10 million. It is significant to note that both firms with revenues greater than $10 million were found to be Canadian subsidiaries which relocated their operations from centres outside Alberta.

Gross revenue trends suggest a healthy high technology sector (refer to Table 7.11). Most respondents (84.6%) stated their gross revenues have been increasing since 1978. Only 3.3% noted declining revenues, while 12.1% indicated a relatively stable revenue trend. A cross tabulation of firm ownership by gross revenue trends since 1978 (Table 7.12) showed that 14 of 15 foreign subsidiaries (93.35) had increasing revenues. Similarly, 86.4% of the independents showed an increasing revenue trend followed by 64.2% of the Canadian subsidiaries. It is significant to note that most respondents (53.2%) projected an annual rate of revenue growth in excess of 20% for fiscal 1984 and 1985 (Table 7.13). An additional 18.1% projected annual revenue growth of 11-19% and 14.9% estimated growth at between 6-10%. Only 4.3% projected a decline in future revenues and 2.1% indicated that revenues would generally show no change. A statistically significant cross tabulation of firm ownership by projected annual rate of growth in gross revenues (Table 7.14) showed that the majority of independent firms (65.6%) estimated revenue growth in excess of 20% per annum compared to 40% of the foreign subsidiaries and 27.2% of the Canadian subsidiaries. However, most Canadian subsidiaries (78.5%) and foreign subsidiaries (71.4%) projected annual revenue growth of 10-19% compared to 25% of the independents. None of the subsidiary firms projected a decline in revenue growth, but 6 independents (93.%) indicated their revenues would be lower.

TABLE 7.11

GROSS REVENUE TRENDS SINCE 1978

Revenues	No. of Responses	%
Increasing	77	84.6
Decreasing	3	3.3
No Change	11	12.1
	91	100.0

TABLE 7.12

CROSS TABULATION OF FIRM OWNERSHIP BY GROSS REVENUES SINCE 1978

Firm Ownership	Increasing	Decreasing	Row Total
Independents	51	8	59
Canadian Subsidiaries	9	5	14
Foreign Subsidiaries	14	1	15
Row Total	74	14	88

Chi square = 4.714 Critical chi square at .05 Significance level = 5.99

Note: The 'Decreasing' and 'No Change' revenue categories were grouped under the heading 'Decreasing' to permit a chi square calculation.

TABLE 7.13

PROJECTED ANNUAL RATE OF GROWTH IN GROSS REVENUES (FISCAL 1984 & 1985)

Projected Annual Increase	No. of Responses	%
0-5%	7	7.4
6-10%	14	14.9
11-19%	17	18.1
>20%	50	53.2
No Change	2	2.1
Decline	4	4.3
	94	100.0

TABLE 7.14

CROSS TABULATION OF FIRM OWNERSHIP BY PROJECTED ANNUAL RATE OF GROWTH IN GROSS REVENUES (FISCAL 1984 & 1985)

Firm Ownership	0-19%	>20%	Decline	Row Total
Independents	16	42	6	64
Canadian Subsidiaries	11	3	0	14
Foreign Subsidiaries	10	4	0	14
Column Total	37	49	6	92

Chi-Square = 22.12 Critical Chi-square at .05 Significance level = 9.49

An analysis of net profit trends since 1978 (Table 7.15) showed that most firms (57.1%) increased their share of net income. Firms experiencing a decreasing net profit trend accounted for 13.2% of the respondents. Similarly, 13.2% showed no change in net profit, while 16.5% were experiencing lossess. A cross tabulation of firm ownership by net profit trends since 1978 (Table 7.16) revealed no significant statistical differences in responses. Of the independents, 60% showed an increasing net profit trend compared to 64.2% of the foreign subsidiaries and 55.5% of the Canadian subsidiaries. With respect to the projected annual rate of net profit growth for fiscal 1984 and 1985 (Table 7.17), 38.3% of the respondents expected net profit to increase by greater than 20%. An additional 19.1% projected increases of 11-19%, while 13.8% estimated an annual net profit growth of between 6-10%. Only 3.2% of the respondents projected a decline in net income. A cross tabulation of firm ownership by projected annual rate of net profit growth (Table 7.18) revealed an identical set of results as shown in Table 7.14 (cross tabulation of firm ownership by projected annual rate of growth in gross revenues). Although these results suggest that net profit growth will match gross revenue growth, it should be noted that this relationship rarely holds true. Different types of firms will use different accounting procedures to derive a net income statement, which in many cases may portray a profit performance unrelated to revenue growth. Nevertheless, the data suggest that the majority of independent high technology firms are enjoying rapid growth in net earnings compared to a generally slower rate of net profit growth by subsidiary firms. While this trend may relate to firm size, that is, proportional increases are always greater for smaller firms, it has provided evidence that the majority of small independent firms are surviving and growing.

Analysis of gross revenue statistics (Tables 7.8-7.13) has revealed that the majority of high technology firms in Alberta, most notably the independents, are in the early stages of growth. Bollinger et al. (1983) noted a tendency for more rapid growth among new high technology firms. These firms were found to achieve rapid growth rates primarily because they were exploiting technological opportunities in an attempt to maximize sales, and therefore establish themselves in the market place. This performance contrasted with larger, more

TABLE 7.15

NET PROFIT TRENDS SINCE 1978

Net Profit	No. of Responses	%
Increasing	52	57.1
Decreasing	12	13.2
No Change	12	13.2
Losses	15	16.5
	91	100.0

TABLE 7.16

CROSS TABULATION OF FIRM OWNERSHIP BY NET PROFIT TRENDS SINCE 1978

Firm Ownership	Increasing	Decreasing	Row Total
Independents	36	24	60
Canadian Subsidiaries	5	9	14
Foreign Subsidiaries	9	5	14
Column Total	50	38	88

Chi square = 3.30 Critical chi square at .05 Significance level = 5.99

Note: 'Decreasing', 'No Change' and 'Losses' categories were grouped under 'Decreasing' to permit chi square calculation.

TABLE 7.17

PROJECTED ANNUAL RATE OF NET PROFIT GROWTH (FISCAL 1984 & 1985)

Rate of Growth	No. of Responses	%
0-5%	18	19.1
6-10%	13	13.8
11-19%	18	19.1
20%	36	38.3
No Change	6	6.4
Decline	3	3.2
	94	100.0

TABLE 7.18

CROSS TABULATION OF FIRM OWNERSHIP BY PROJECTED ANNUAL RATE OF NET PROFIT GROWTH (FISCAL 1984 & 1985)

Firm Ownership	0-19%	20%	Decline	Row Total
Independents	16	42	6	64
Canadian Subsidiaries	11	3	0	14
Foreign Subsidiaries	10	4	0	14
Column Total	37	49	6	92

Chi square = 22.12   Critical chi square at .05 Significance level = 9.49

Note: Categories for projected annual rate of increases in net profit were grouped to permit chi square calculation.

established firms, which generally placed emphasis on production-related factors directed at minimizing costs and protecting market share.[2] Although gross revenue and net profit trends showed no difference in responses among high technology firms in Alberta, a tendency toward more rapid rates of revenue and profit growth was exhibited by small to medium-sized independent firms. These results are similar to Bollinger's findings and support acceptance of research hypothesis 2.1. However, it is cautioned that these results are general in nature and have been used to provide an overview of business progress. While it is recognized that projected annual rates of gross revenue and net profit growth may reflect an entrepreneur's expectations rather than forecasts based on comprehensive financial data, there are significant constraints to obtaining detailed financial information and subsequently evaluating commercial performance. In Litvak and Maule (1980) it was noted that:

> "Performance data for smaller companies are difficult to interpret. In closely-held companies, reported profits may be minimized through large executive salaries and perquisites and through payments to relatives. New companies, particularly those which are growth oriented, may invest heavily in product and market development, resulting in losses or low profits even when the firms are well managed. Furthermore, the corporate goals may be interwined with the personal values of the owner managers to a marked degree; the satisfactions and lifestyles of the founders may be difficult to measure in any systematic way."[3]

Growth Rates by High Technology Sector

Research Hypothesis 2.2:

That high technology sectors exhibit a wide variety of experiences in gross revenue and net profit growth.

Research Hypothesis 2.3:

That high technology firms directly associated with Alberta's resource industries have been generally more successful than others.

To address research hypotheses 2.2 and 2.3, categorization of high technology firms by major product or service was cross tabulated by gross revenue trends since 1978, projected annual rate of growth in gross revenues for fiscal 1984 and 1985, net profit trends since 1978 and projected annual rate of net profit growth for fiscal 1984 and 1985.

Analysis of these data showed no statistically significant differences in revenue and profit performance among Alberta's high technology sectors. Firms in all groups showed increasing gross revenue trends since 1978.

The largest proportion of firms with increasing gross revenues were in the Electronics and Communications sector (89.2%), followed by Computer firms (86.9%), Miscellaneous high technology firms (82.3%), Consulting Service firms (77.7%) and the Petroleum industry (66.6%). Net profit growth since 1978 was less pronounced, but a generally increasing trend in earnings was found. Most firms showing an increasing net profit trend were in the Consulting Services group (77.7%) followed by the Electronics and Communications sector (64.2%), Computer firms (56%), the Petroleum industry (50%) and Miscellaneous high technology firms (50%). With respect to projected annual rate of growth in gross revenues for fiscal 1984 and 1985, most Computer firms (75%) estimated their annual rate of revenue growth at greater than 20%. Firms directly associated with the Petroleum industry ranked next (66.6%) followed by Electronics and Communications firms (56.6%), Miscellaneous high technology firms (43.7%) and Consulting Service firms (14.2%). Projected annual net profit growth of greater than 20% was estimated by 50% of the respondents in the Petroleum and Computer categories. Electronics and Communications firms ranked next (40%), followed by Miscellaneous high technology firms (38.8%). No firms in the Consulting Services sector projected annual net profit growth at 20% or greater.

In summary, increasing revenue trends were found to be the strongest among Electronics and Communications firms, but increasing net profit trends were found to be greater in Consulting Service firms. Computer firms generally projected the highest percentages increases in future revenue growth, while the largest percentage increases in net profit growth were estimated by firms in the Petroleum and Computer categories. These results suggest that high technology firms in Alberta exhibit diverse revenue and profit growth. However, no particular high technology group was found to be generally more successful than others. Therefore, hypothesis 2.2 is accepted, while hypothesis 2.3 is not accepted.

Research and Development (R&D) Activity

Research and Development (R&D) is considered by many analysts to be a fundamental characteristic of high technology firms. More importantly, it has been demonstrated that most Canadian high technology executives perceive it as being crucial to the long-term survival of their firms.[4] In Alberta, very little is known about the incidence and structure of R&D programs carried out by high technology firms. In addition, the level, focus, type and orientation of R&D effort, and important external linkages require clarification. The purpose of this section is to review selected elements of R&D behaviour to attain a greater understanding of its level of importance to high technology firms in the province.

Research Hypothesis 2.4:

> That most Canadian and Foreign controlled subsidiaries carry out their R&D programs outside Alberta.

Tables 7.19-7.20 illustrate the incidence of R&D among high technology firms in Alberta. Most high technology firms (79.1%) were found to perform R&D compared to 20.9% that did not. More importantly, 78 of 91 R&D performing firms (85.7%) conducted their programs in Alberta. A statistically significant cross tabulation between firm ownership and R&D activity showed that all independent firms (100%) conducted their R&D In the province compared to 21 of 34 subsidiaries (61.7%). It should also be noted that the sample included two Crown corporations, both of which were found to conduct R&D in Alberta. Of the subsidiary firms, 13 of 18 Canadian subsidiaries (72.2%) and 8 of 16 foreign subsidiaries (50%) carried out research and development programs in Alberta. It is clear that most subsidiaries of firms with head offices elsewhere conduct R&D in the province. Hypothesis 2.4 is not accepted.

TABLE 7.19

RESEARCH & DEVELOPMENT ACTIVITY IN ALBERTA

R&D Effort	No. of Responses	%	R&D in Alberta	%
Performs R&D	91	71.9	78	85.7
No. R&D	24	20.9		
	115	100.0		

TABLE 7.20

CROSS TABULATION OF FIRM OWNERSHIP BY R&D ACTIVITY IN ALBERTA

Firm Ownership	R&D Inside Alberta	R&D outside Alberta	Row Total
Independents	55	0	55
Canadian Subsidiaries	13	5	18
Foreign Subsidiaries	8	8	16
	76*	13	89

Chi square = 27.98016 Critical chi square at .05 Significance level = 5.99

- Two Crown corporations were also found to conduct R&D in Alberta making the total 78 firms. This information was not included in this cross tabulation to permit chi square analysis.

Type of R&D Program

Oakey (1983a) found that part-time research and development is common in small high technology firms. R&D is usually conducted by a technologically oriented entrepreneur during a time when other corporate duties are less demanding. Such programs are often undertaken on an informal basis and represent a compromise between the need to be innovative and the high cost of employing full-time professional R&D staff. On the other hand, full-time R&D evolves from growth of the firm which allows for a necessary organizational change that includes a full-time R&D staff. Full-time R&D may comprise several projects which, because of the relatively high cost and risk, necessitates a more structured planning and budgetary process. Overall, it becomes evident that the transition from no R&D effort, to part-time projects, to the establishment of full-time R&D relates to firm size.[3]

Research Hypothesis 2.5

> That most small high technology firms conduct part-time R&D programs compared to medium-sized and large high technology firms which carry out full-time R&D, and that most high technology firms prepare an R&D budget.

Full-time R&D programs (64.9%) were found to be more common in Alberta's high technology firms than part-time R&D (35.1%) (Table 7.21). In addition, most respondents prepared a planned R&D budget (54.7%) compared to 45.3% which did not (Table 7.22). A cross tabulation between firm size and type of R&D program showed that all large high technology firms (100%) conducted full-time R&D. Most medium-sized firms (61.5%) were also found to perform full-time R&D. However, an unexpected 61.4% of the small high technology respondents indicated that their R&D efforts were conducted on a full-time basis (Table 7.23). Based on these results the first part of hypothesis 2.5 is not accepted while the second part related to R&D budget preparation is accepted. A comparison between the level of research and development effort in Alberta with three other high technology regions is provided in Table 7.24. It is interesting to note that the largest percentage of firms engaged in full-time R&D were found in the two peripheral regions: Scotland (64.3%) and Alberta (62.7%). These

TABLE 7.21

TYPE OF R&D PROGRAM

R&D EFFORT	No. of Responses	%
Full-time	50	64.9
Part-time	27	35.1
	77	100.0

TABLE 7.22

PLANNED R&D BUDGET

Response	No. of Responses	%
Yes	41	54.7
No	34	45.3
	75	100.0

TABLE 7.23

CROSS TABULATION OF FIRM SIZE BY TYPE OF R&D PROGRAM

Firm Size	Full-time	Part-time	Row Total
Small (<100 employees)	35	22	57
Medium (100-999 employees)	8	5	13
Large (>1,000 employees)	4	0	4
Column Total	47	27	74

Chi square = 1.6568 Critical chi square at .05 Significance level = 5.99

TABLE 7.24

LEVEL OF RESEARCH & DEVELOPMENT COMMITMENT BY REGION

R&D Effort	Alberta		Scotland		S.E. England		San Francisco Bay Area	
	No.	%	No.	%	No.	%	No.	%
Full-time	42	62.7	27	64.3	20	39.2	29	52.7
Part-time	25	37.3	15	35.7	31	60.8	26	47.3
Total	67	100.0	42	100.0	51	100.0	55	100.0

Note: Oakey defined small high technology firms as having less than 200 employees. Data from the Alberta survey was adjusted for comparison purposes.

Source: Adapted from R.P. Oakey, Research & Development Cycles, Investment Cycles and Regional Growth in British and American Small High Technology Firms, University of Newcastle upon Tyne Centre for Urban and Regional Development Studies. Discussion Paper No. 48, August, 1983a, p. 16.

levels are significantly greater than firms located in the core high technology regions of South East England (39.2%) and the San Francisco Bay Area (52.7%). Despite this imbalance, Oakey (1983a) citing the number of commercial innovations produced as a measure of regional innovative performance, concluded that most Scottish firms were "notably backward"[6] when compared with firms located in South East England and the San Francisco Bay Area. However, this trend was expected mainly because Scottish high technology firms are significantly younger than their counterparts in these two regions. Although different age categories were used in the Alberta survey, a cross tabulation between firm age and type of R&D program suggests that Alberta's R&D efforts bear a closer resemblance to the Scottish example in that the majority of firms engaged in full-time R&D (67.4%) are less than 10 years old. (Refer to Tables 7.25-7.26).

Oakey concluded that presence of full-time R&D might not be an accurate measure of R&D effort. Although he suggested that incidence of product innovation was more indicative of regional innovation performance, this measure does have its limitations. New product sales, market position and degree of patent protection have all been used with varying degrees of success. However, because some industries are more innovative and technically sophisticated than others and innovations can take on many different forms, consistent methods for measuring the quality of R&D output and success are constrained. Moreover, Oakey found that high technology product cycles can be very short which suggests that a firm's ability to continually innovate may be more important than past innovations produced. This perspective is shared by Browne (1983b) who notes that "the high technology industries of the future will not necessarily be those we call high technology today".[7] Although there is no way of knowing a firm's future innovative performance, the focus of R&D behaviour with regard to technology strategy may be a useful indicator.

TABLE 7.25

FIRMS WITH FULL-TIME R&D BY AGE AND REGION

Age	Scotland		South East England		San Francisco Bay Area	
	No.	%	No.	%	No.	%
Pre 1970	5	19	14	70	16	55
Post 1970	22	81	6	30	13	45
total	27	100	20	100	29	100

Source: Oakey, op cit. (1983a), p. 16.

TABLE 7.26

CROSS TABULATION OF FIRM AGE BY TYPE OF R&D PROGRAM

Firm Age	Full-time R&D		Part-time R&D		Row Total
	No.	%	No.	%	
< 5 Years	19	44.2	10	40.0	20
6-10 Years	10	23.2	6	24.0	16
>10 Years	14	32.6	9	36.0	23
Column Total	43	100.0	25	100.0	68

Chi Square = .122 Critical chi square at .05 Significance level = 9.49

Note: Only firms with less than 200 employess were included in this calculation in order to permit a general comparison with Table 7.25.

R&D Focus

Research Hypothesis 2.6:

> That investment in R&D is focused on adaptations of existing products and processes rather than new product/process development.

R&D focus was examined by measuring the percentage of research and development expenditures allocated for new product/process development versus adaptations to existing products and processes. These results are shown in Table 7.27. Surprisingly, (see below), most respondents (62.4%) spent greater than 50% of their R&D budget on new product/process development. Firms allocating the largest proportion of their R&D funds for adaptations to existing products/processes accounted for 18.8% of the responses, while an additional 18.8% evenly distributed R&D expenditures between both categories. Clearly, hypothesis 2.6 is not accepted.

A cross tabulation of firm ownership by R&D focus found that most independents (67.3%) concentrated their research and development efforts on new product/process development. Only 12.3% emphasized their R&D approach on improving existing products/processes, while 20% distributed their expenditures evenly between both categories. Due to the relatively few responses from Canadian and foreign subsidiaries, the two categories were combined with responses from Crown corporations. Most subsidiary firms and Crown corporations (46.7%) allocated their R&D expenditures primarily for new product/process development (Table 7.28). However, 6 of 15 firms (40%) concentrated their efforts on improving existing products/processes.

These results indicate that most high technology firms in Alberta, particularly the small to medium-sized independents, have adopted an offensive R&D strategy. An offensive strategy involves striving for technical and market leadership by staying ahead of competitors in new product/process development. A trend toward this type of innovation strategy was not expected for several reasons.

TABLE 7.27

R&D FOCUS

R&D Expenditures >50% of Budget	No. of Responses	%
New Product/Process Development	43	62.4
Adaptations to Existing Products/Processes	13	18.8
Budget Evenly Distributed Between Both	13	18.8
Total	69	100.0

TABLE 7.28

CROSS TABULATION OF FIRM OWNERSHIP BY R&D FOCUS

Firm Ownership	New Product/Process Development	Adaptations to Existing Products/ Processes	Evenly Distributed	Row Total
Independents	37	7	11	55
Subsidiaries & Crown Corporations	7	6	2	15
	44	13	13	70

Chi Square = 4.114 Critical chi square at .05 Significance level = 5.99

First, Steed's survey of 24 R&D performing threshold firms (1982) found that most firms adopted a defensive approach to R&D. Emphasis was placed on incremental improvements or minor adaptations rather than new product development. Thus, R&D focus was generally on lower risk projects in areas closely related to their current market and technological expertise.[8] Secondly, new product/process development carries a considerably higher degree of risk and financial cost. It would be expected that most small to medium-sized high technology firms would not have the financial capacity to sustain heavy losses from unsuccessful R&D efforts. Finally, an offensive R&D strategy requires extensive internal research capabilities and technical research contacts. Among threshold firms Steed found that most R&D was performed without formal organization. These factors do not, however, take into consideration the level of ambition in the management approach or the sophistication of the product/process technology, both of which influence R&D strategy, and subsequently, the level of R&D commitment and financial investment. Moreover, the majority of respondents in this sample have not evolved to threshold status, which may account for many of the differences cited here.

R&D Orientation: Internal vs. External R&D

R&D orientation refers to the development of new products and processes or the improvement of existing ones which are conducted primarily within the firm (internal R&D) or by groups outside the firm (external R&D). Oakey (1983a) notes that virtually all high technology firms with a newly developed product will attempt to preserve their competitive edge through an internal R&D program. However, Steed (1982) contends that a major determinant of success is the extent to which firms and agencies co-operate in their R&D efforts. External contacts are seen as providing a significant source of ideas and assistance. They can reduce reliance on internal R&D, particulary in small high technology firms, by providing technical expertise in certain areas which may be lacking in the firm and through access to expensive test facilities and equipment. In Alberta, it is not known whether the majority of firms carry out their R&D internally or contract projects to external organizations. In addition, the importance of external contacts and the frequency to which they are used requires clarification.

Research Hypothesis 2.7:

> That R&D programs carried out by independent high technology firms are primarily contracted to external groups and agencies.

R&D orientation is shown in Table 7.29. It is significant to note that 96.1% of the respondent firms were found to conduct most of their R&D internally. Only 1 firm (1.3%) emphasized external R&D orientation, while 2 firms (2.6%) emphasized equally both approaches. Based on these results, hypothesis 2.7 is not accepted.

A comparison of the incidence of internal R&D by region indicates that the majority of high technology firms maintain an internal R&D effort (Refer to Table 7.30). The combined results showed that only 47 of 260 firms (18%) performed no R&D. However, from a regional perspective, it is significant to note that the largest number of firms with no R&D program were found in the two peripheral regions: Alberta (24.4%) and Scotland (22.2%).

The emphasis placed on internal R&D by high technology firms should not preclude the importance of external R&D links. Steed (1982) and Oakey (1983a) suggest that external R&D and technical contacts play a supportive role in enhancing the overall internal R&D effort of the firm. Most high technology respondents (40.6%) were found to maintain two or more external R&D links. Firms which maintained at least one external R&D contact accounted or 34.8% of the responses, while 24.6% had no contacts with external groups or agencies (Table 7.31). Table 7,32 ranks the external R&D groups and agencies in the order of importance identified by the high technology respondents A strong reliance on private sector consulting firms (50.7%) for external R&D support was indicated by most respondents. However, interaction with universities (39.1%) was found to be an frequent external R&D contact, followed by the Alberta Research Council (30.8%). The National Research Council, which maintains a close liaison and jointly funds many programs with the Alberta Research Council, ranked next (18.8%). Contacts with provincial government departments were significantly less

TABLE 7.29

R&D ORIENTATION

R&D Orientation	No. of Responses	%
Internal	73	96.1
External	1	1.3
Both	2	2.6
Total	76	100.0

TABLE 7.30

INCIDENCE OF INTERNAL R&D BY REGION

R&D Effort	Alberta		Scotland		S.E. England		San Francisco Bay Area	
	No.	%	No.	%	No.	%	No.	%
Internal	65	75.5	42	77.8	51	85.0	55	91.7
No R&D	21	24.6	12	22.2	9	15.0	5	8.3
Total	86	100.0	54	100.0	60	100.0	60	100.0

Source: Adapted from Oakey (1983a), op cit., p. 13.

TABLE 7.31

LEVEL OF EXTERNAL R&D CONTACTS

External R&D	No. of Responses	%
Two or more Contacts	28	40.6
One Contact	24	34.8
No Contact	17	24.6
	69	100.0

TABLE 7.32

EXTERNAL R&D LINKAGES

Rank	Group/Agency	No. of Responses	% of Firms
1	Private Consulting Firms	35	50.7
2	Universities	27	39.1
3	Alberta Research Council	21	30.4
4	National Research Council	13	18.8
5	Provincial Government Dept.'s	9	13.0
6	Other Firms	4	5.7
7	Electronics Test Centre	1	1.4
8	Other	1	1.4
		111	

N = .69

frequent with only 9 of 69 firms (13%) maintaining a technical link. The Electronics Test Centre, which was cited as an important R&D link by one firm, was only recently established, which may account for the low frequency of contact with high technology firms. A comparison of external R&D contacts by region is shown in Table 7.33. Surprisingly, the highest level of external R&D links by region were found in Alberta (72.9%) and Scotland (55.6%), while the lowest were recorded by the San Francisco Bay Area firms (23.3%). These results suggest there is little correlation between the most innovative region and extensive local and regional links with external research groups.[9] In addition, the results suggest considerably stronger internal research capabilities, that is, highly skilled professional R&D staff in the San Francisco Bay Area than in Scotland and Alberta. The low level of external research and development links with San Francisco Bay Area firms was unexpected primarily because most of the respondents in that survey were located in Silicon Valley, within 10 miles of Stanford University. The role played by Stanford in collaborating with industrial research efforts has been well-documented. However, Oakey's survey indicates that Stanford's role as an external facilitator of R&D has declined as the regional economy matured, but that it continues to act as an incubator of new firms. Thus, the evidence which indicates that universities play a relatively important role in establishing external R&D links with high technology firms in Alberta and Scotland might represent an evolutionary phase in the development of high technology regions. In Alberta, it may be the result of recent funding of new programs in Universities by the Provincial Government.

R&D Funding

Funding for R&D can be derived from many sources. It can be generated internally by the company (retained earnings), externally from private investors or other firms (joint venture), through government support (tax incentives and/or financial grants) or any combination of these sources.

Government assistance programs were expected to be the primary source of funding for Alberta's independent high technology firms for several reasons. First, the federal government sponsors several grant and tax incentive programs for R&D funding. In particular, the recently cancelled Science & Research Tax Credit Program (SRTC) was a popular investment vehicle for most independent firms. Secondly, the Alberta provincial government maintains a higher level of R&D investment than any province in the country. Finally it was hypothesized that most independent high technology firms do not have the internal financial resources or external bank credit lines to support continuous R&D. Financial positions were believed to remain financially weak as a result of the severe economic downturn which began in 1981, and was recently climaxed by the failure of two provincially based chartered banks.

Research Hypothesis 2.8:

> That R&D programs carried out by independent high technology firms are funded primarily by federal and provincial government assistance programs.

Most high technology firms (57.3%) cited retained earnings as their primary source of R&D funding (refer to Table 7.34). Private investors ranked next (13.3%), followed by firms with more than one primary source of R&D funds (12.0%). Federal and provincial government programs were found to be major sources of financing for only 7 of 76 firms (9.4%).

Although most high technology firms did not cite government as their major source of R&D funding, 41.9% of the respondents acknowledged receipt of some form of government financial assistance to support their R&D efforts (Table 7.35). Approximately one of every three respondents received their assistance from the federal government, while 13 of 74 firms (17.6%) were recipients of financial support from the provincial government. A cross tabulation of firm ownership by government financing of R&D (Table 7.36) showed that 23 of 52 (44.2%) independent firms received R&D funding support from the federal and/or provincial governments compared to 6 of 13 (46.1%) of the Canadian subsidiaries. Only one foreign subsidiary indicated that it had received government financial assistance for R&D.

TABLE 7.33

EXTERNAL R&D CONTACTS BY REGION

External	Alberta		Scotland		S.E. England		San Francisco Bay Area	
	No.	%	No.	%	No.	%	No.	%
External Contacts	43	72.9	30	55.6	25	42.4	14	23.3
No Contacts	16	27.1	24	44.4	34	57.6	46	76.7
Total	59	100.0	54	100.01	59	100.0	60	100.0

Source: Adapted from Oakey (1983a), op cit., p. 20.

TABLE 7.34

PRIMARY SOURCES OF R&D FUNDING

Financial Source	No. of Responses	%
Retained Earnings	43	57.3
Private Investors	10	13.3
More than 1 Source	9	12.0
Federal government	5	6.7
Joint Venture	2	2.7
Provincial Government	2	2.7
Other	4	5.3
Total	75	100.0

TABLE 7.35

GOVERNMENT FINANCING OF R&D

Source of Assistance	No. of Responses	%
Federal Government	18	24.3
Provincial Government	6	8.1
Both	7	9.5
No Assistance	43	58.1
Total	74	100.0

TABLE 7.36

CROSS TABULATION OF FIRM OWNERSHIP BY GOVERNMENT FINANCING OF R&D

Firm Ownership	Provincial Government	Federal Government	Both	No Assistance	Row Total
Independents	5	13	5	29	52
Canadian Subsidiaries	0	4	2	7	13
Foreign Subsidiaries	0	1	0	5	6
	5	18	7	46	71

Chi square = 3.90542 Critical chi square at .05 Significance Level = 12.59

It is evident from these results that although a proportionally large number of independent high technology firms make use of government financial assistance for R&D, these programs do not provide the primary source for R&D funding in independent firms. Therefore, hypothesis 2.8 is not accepted.

Employment Growth

Employment opportunities for Albertans have become a growing concern in a narrowly based resource economy that has been affected by boom and bust cycles. As a result of the latest oil and gas boom, the total employed labour force grew by 38% between 1974 and 1980, with a net gain of 297,000 jobs. However, between 1980 and 1984 the labour force grew by only 3.1%, a net gain of only 36,000 jobs during that period. Changes in the provincial labour force by industrial group (Table 7.37) showed the largest net job gains were in the Public Administration (+21.4%) and Service sectors (+18.9%), while the largest losses were in Construction (-31.7%) and Manufacturing (-13.7%). Modest gains were recorded in Agriculture (+3.5%) and Primary Resources (+12.1%). In terms of unemployment, in 1980 Alberta enjoyed the lowest unemployment rate in Canada (3.7%). This rate was slightly less than one-half the national average (7.5%). By 1984, unemployment had risen to 11.2%, a rate equal to the national average. While many reasons have been cited for the recent economic decline, it is becoming more evident that the Alberta government can not rely solely on the province's resource base to provide future job opportunities. The recently published government White Paper (1984) identifies high technology as a potential new source of job opportunities. However, the pattern of employment trends, in addition to the occupational structure exhibited by Alberta's high technology firms has not been addressed. Examination of this issue is critical because employment growth is the single most important element of regional economic development.

Research Hypothesis 2.9:

TABLE 7.37

EMPLOYED LABOUR FORCE BY INDUSTRIAL SECTOR IN ALBERTA – 1980-1984

Year	Total	Agriculture	Primary	Manufacturing	Construction	Transportation
1980	1,078,000	85,000	66,000	102,000	104,000	97,000
1984	1,114,000	88,000	74,000	88,000	71,000	95,000
Gain (Loss)	3.1%	3.5%	12.1%	(13.7%)	(31.7%)	(2.0%)

Year	Trade	Finance	Service	Public Administration
1980	195,000	59,000	301,000	70,000
1984	196,000	58,000	358,000	85,000
Gain (Loss)		(1.7%)	18.9%	21.4%

Source: Alberta Bureau of Statistics. Alberta Statistical Review, Third Quarter, 1985. November, 1985 p. 33.

That high technology firms have not created much direct employment in Alberta.

The total full-time labour force of the respondents was 27,288. However, 20,262 (74.2%) was accounted for by just four large firms: two Canadian subsidiaries, one foreign subsidiary and a Crown corporation. A cross tabulation of firm ownership by full-time employment (refer to Table 7.38) showed that although independent firms comprised 65.9% of the respondents, they accounted for only 1,949 or 7.1% of the total number of full-time employees. The large proportion of small independent high technology firms found in the questionnaire and non-respondent samples, in addition to the very small and very large subsidiary firms identified, pose difficulties in projecting Alberta's total high technology labour force. Moreover, because high technology firms occur in all industrial sectors the problem of double counting exists.

Data concerning employment change during the five year period 1980-1984 may be a useful indicator as to the job creation power of high technology firms in Alberta. Most firms (74.2%) indicated that they created full-time jobs since 1980 (Table 7.39). Firms which reduced staff acounted for 20.2% of the respondents, while 5.6% had no change in their staff complements.

The total net change in employment from 79 respondents accounted for a gain of 2,120 direct full-time jobs or an average of 27 employees per firm for the five years preceeding this survey. To put this total in perspective, the combined number of full-time jobs created by both the agricultural and primary industry sectors during the same period was 11,000 jobs. Although the problem of double counting remains, the data suggests that high technology firms have been responsible for creating as much as or more direct full-time employment than the agricultural and primary resource sectors combined. However, it is questionable whether net employment gains generated by high technology firms during the period 1980-1984 have been sufficient to offset the decline in manufacturing employment.

The employment contribution from new high technology firms is critical to the long-term development of a regional high technology base. Although employment size may be

TABLE 7.38

FIRM OWNERSHIP BY TOTAL NUMBER OF FULL-TIME EMPLOYEES

Firm Ownership	No. of Firms	No. of Full-time Employees	%
Independents	62	1,949	7.1
Canadian Subsidiaries	15	8,143	29.9
Foreign Subsidiaries	16	6,084	22.3
Crown	1	11,112	40.7
	94	27,288	100.0

TABLE 7.39

EMPLOYMENT CHANGE 1980-1984

Observation	No. of Responses	%
Created Employment	66	74.2
Reduced Staff	18	20.2
No Change	5	5.6
	89	100.0

of minor significance to regional economies during the early stages of growth, a small number of fast growing firms can have a significant impact on employment growth over a period of several years. Many American examples, such as Apple Computer Ltd. and Texas Instruments Ltd., which now employ thousands of workers, are evidence of such trends. A comparison of firms less than 5 years in age by region with the total number of jobs created and the average number of jobs per firm is provided in Table 7.40.

It is significant to note that young San Francisco Bay Area firms exhibited much faster employment growth rates than high technology firms in Alberta, Scotland, and South East England. In fact, they were approximately four times larger than the average firm in Alberta and Scotland. it was suggested that Bay Area firms experienced faster employment growth rates as a result of their location within a high technology agglomeration.[10] Although the average employment size among young high technology firms in Alberta was less pronounced than in the core high technology regions, survival of these firms through the first five years of operation not only increases the probability of future growth, but completes a critical phase in the establishment of a high technology base.

Employment Structure

Employment structure was determined by the types of occupations found in Alberta's high technology firms and the types of jobs created during the five years preceeding this survey. Unfortunately, the data summarized here can not be compared with other industrial sectors because different occupational categories are used to compile statistics. Moreover, it has only been very recent that other regions have begun to compile separate statistics on high technology occupations.[11]

Research Hypothesis 2.10:

> That new high technology employment created has been largely in routine, low skilled, low paying non-professional positions as opposed to highly skilled, high paying professional and technical employment.

TABLE 7.40

JOBS CREATED IN FIRMS LESS THAN FIVE YEARS OLD BY REGION

Observation	Alberta	Scotland	S.E. England	San Francisco Bay Area
No. of Firms	31	16	3	14
Total Jobs	544	251	78	796
Average/Firm	17	16	26	57

Note: The Alberta data does not include firms which relocated from outside the province.

Source: Adapted from Oakey (1983a), op cit., p. 24.

A summary of the existing employment structure found in Alberta's high technology firms is shown in Table 7.41. Most occupations were in the non-professional category (51.4%) compared to 48.6% in the professional and technical group. The largest single occupational group (35.2%) was comprised of general non-professional positions (service, trade, field and production staff), but sizeable representation was found in the technician/technologist (17.6%) and engineering (16.3%) categories, which combined, accounted for approximately one out of every three positions. However, it is significant to note that a larger proportion of the jobs created during the period 1980-1984 were in the non-professional category (67.2%) (Table 7.42) compared to 32.8% in professional and technical jobs. These results may account for the fact that 69 of 95 firms (72.6%) experienced no difficulties in hiring personnel. For the 27.4% of firms which experienced hiring difficulties, the lack of skilled personnel was the main problem. According to Weiss (1985) (in Hall and Markusen) an employment structure comprised largely of low paid, low skilled labour and relatively fewer high paid, high skilled professionals is a prominent characteristic of the high technology sector. He refers to this characteristic as the "dual labour force"[12] and suggests that the lack of union organization has kept non-professional wages and benefits significantly lower than in unionized blue collar positions.[13] It is worth noting that 94 of 98 respondent firms (95.9%) were staffed entirely by non-union employees. Unfortunately, the absence of information concerning wages and lack of comparative financial data from other high technology regions constrains further exploration of this issue. Overall, this survey found that the majority of high technology jobs in Alberta's high technology sector are non-professional positions and that a trend toward job growth in non-professional areas was indicated. Hypothesis 2.10 can be accepted.

Markets & Competition

In recent years focus has been placed on expanding export markets and maintaining a competitive technological edge in product/process development in order to stay ahead of competitors. Because demand for high technology products and services has been strong,

TABLE 7.41

HIGH TECHNOLOGY EMPLOYMENT STRUCTURE

Occupation	No. of full-time Employees	%
(Professional)		
Scientists	680	8.2
Engineers	1,347	16.3
Technicians/Technologists	1,454	17.6
Managers/Administrative	533	6.5
		48.6
(Non-Professional)		
General (Service, trade, field & production)	2,906	35.2
Salesman	293	3.5
Clerical	1,046	12.7
		51.4
N = 83		
Total	8,259	100.0

TABLE 7.42

TYPE OF EMPLOYMENT CREATED (1980-1984)

Occupation	No. of full-time Employees	%
(Professional)		
Scientists	53	2.3
Engineers	161	7.0
Technicians/Technologists	409	17.9
Managers/Administrative	128	5.6
		32.8
(Non-Professional)		
General (Service, trade, field & production)	1,209	52.8
Salesman	153	6.7
Clerical	173	7.7
		67.2
N = 68		
Total	2,286	100.0

foreign markets have evolved quickly, which in turn has spurred growth. Thus, survival and success of many high technology firms has depended on establishing a geographically diversified export market.

Market share

In this survey market performance was measured by determining the percentage of sales generated in Alberta, other Canadian and foreign markets, followed by a comparison of sales generated by location for 1980 and 1985. The intent was to determine the predominant market being served by high technology firms in Alberta and whether any changes in market share have occurred.

Research Hypothesis 2.11:

That high technology firms generate most of their sales in Alberta before achieving significant export sales to the United States and other foreign markets.

A cross tabulation of firm ownership by market share is shown in Table 7.43. High technology firms were found to rely primarily on local markets in Alberta (48.61%) to sell their goods and services. Canadian markets outside Alberta ranked next (35.02%), with foreign markets comprising the lowest percentage market share (16.37%). Although local markets were found to be of greater importance to independent firms (61.5%), this group had a propensity to export abroad (20.35) comparable to Canadian subsidiaries (20.8%) and much greater than foreign subsidiaries (8.0%). The low export propensity exhibited by foreign subsidiaries suggests that these branch plants lack a world product mandate. These results contrast considerably with Steed and DeGenova's (1983) findings of high technology firms in the Ottawa-Carleton region. In that study high technology firms were found to have a much higher foreign export propensity (34%) with the highest market share being generated by foreign subsidiaries (40%). On average, domestic Canadian companies generated 32% of their sales to foreign markets.[14] It was suggested that foreign subsidiaries maintained a high export propensity because of management initiative and perhaps, their proximity to large markets in the United States.

A comparison between present sales markets (largest percentage of sales) and 1980 sales markets is shown in Table 7.44. It is interesting to note that although firms continued to sell the largest proportion of their goods and services inside Alberta, a general trend toward establishing stronger market positions elsewhere was found. Firms with the largest market share in Western Canada (excluding Alberta) increased from 17 to 20 (18.5% to 22%). More significantly, the number of firms with the largest percentage of sales to the United States doubled from 7 to 14 firms (7.6% to 15.4%). Unfortunately, there is no way of knowing whether the stronger sales to American markets can be attributed to management initiative or to a Canadian dollar which has declined considerably against its American counterpart since 1980, making Canadian goods and services more attractive for import.

With respect to international markets in general, 47.8% of the respondent firms did not generate any exports outside Canada (Table 7.45). Firms which established or increased their share of sales to international markets accounted for 34.8% of the replies, while 17.4% experienced no change or a decline in sales to foreign sources. Of those firms which increased their share of international export sales, 93.8% were found to perform R&D in Alberta. However, 81.5% of the firms which experienced no change or a decline in export sales also performed R&D in the province. The smallest proportion of R&D performing firms (68.2%) had no export sales to international markets. These results suggest that presence of R&D may not necessarily be a causative factor behind increased foreign export sales.

Only 21 of 91 firms (23%) generated 30% or more of their sales in international markets. It is significant to note that 15 of these firms (71.4%) were independents with 5 Canadian subsidiaries and 1 foreign subsidiary accounting for the remaining six firms. Eleven of the 21 firms (52.4%) were established more than ten years ago. Of the independents, 14 of 15 (93.3%) were small in size, while only 6 of 15 (40%) were less

TABLE 7.43

CROSS TABULATION OF FIRM OWNERSHIP BY AVERAGE MARKET SHARE(%)

Firm Ownership	No. Responses	Market Share Alberta(%)	Canadian (%)	Foreign (%)
Independents	58	61.5	18.2	20.3
Canadian Subsidiaries	15	35.6	43.6	20.8
Foreign Subsidiaries	12	48.75	43.25	8.0
	85			
Ave.		48.61	35.02	16.37

TABLE 7.44

COMPARISON OF SALES MARKETS: 1980, 1985 (LARGEST MARKET SHARE BY % OF SALES ONLY)

Location	No. of Responses 1980	1985	% 1980	% 1985
Alberta	41	40	44.5	44.0
Western Canada (excluding Alberta)	17	20	18.5	22.0
Eastern Canada (east of Manitoba)	11	12	12.0	13.2
United States	7	14	7.6	15.4
Foreign (excluding U.S.A)	2	3	2.2	3.3
No Sales		2		2.1
Firm did not exist in 1980	14		15.2	–
	92	91	100.0	100.0

TABLE 7.[illegible]

CHANGES IN INTERNATIONAL MARKET SHARE 1980-1985 (% of Sales)

Market Share	No. of Responses	%	Presence of R&D		% Yes
			Yes	No	
Established or increased export sales to international markets since 1980	32	34.8	30	2	93.8
No change/decline in international export market share since 1980	16	17.4	13	3	81.5
No international markets	44	47.8	30	14	68.2
	92	100.0	73	19	

than five years old. No independent firms generated more than 10 million in annual revenues, while 8 of 15 firms (53.3%) had less than 1 million in annual revenues. In contrast, 4 of the 6 subsidiaries were medium-sized firms, in addition to one large firm and one small one. However, 5 of the 6 subsidiaries were more than ten years old, with the sixth relocating from another province during the last five years. None of the subsidiary firms had annual revenues of less than $1 million and 4 of 6 firms generated revenues in excess of $10 million per annum. Of the independents, 8 of 15 (53.3%) firms established subsidiaries elsewhere. Most of these locations were in the United States. The choice to expand operations outside Canada suggests that a geographic diversification strategy is important to most of those firms.

Thus, it is evident that most export-oriented high technology firms are small in size, but were founded more than ten years ago. Moreover, these results suggest that international export competitiveness for these firms is not related to large size and scale economies, but that a considerable length of time was required to penetrate foreign markets.

Electronics and Communication firms showed a higher propensity for international exports accounting for 9 of the 21 firms (42.9%) Four respondents were Computer related firms (19%), followed by two each in the Petroleum Industry (9.5%), Consulting Services (9.5%) and Miscellaneous Manufacturing (9.5%) sectors. The remaining two respondents included an Agricultural company (4.8%) and one Biomedical firm (4.8%). Based on the type of product or service provided, 15 of 21 firms (71.4%) were not directly or indirectly related to the oil and gas industry.

In summary, this analysis has demonstrated that high technology firms in Alberta have a generally low foreign export propensity and rely on local markets inside the province for the largest proportion of their sales. Hypothesis 2.11 in accepted.

Marketing Assistance

Marketing has been identified as a critical factor to the survival and growth of high technology firms. In fact, the inability to market products and services was found to be a major factor contributing to the large number of high technology failures in Canada.[15] This finding suggests that most independent high technology firms require some form of marketing assistance. In Alberta, government marketing assistance programs were expected by this writer to be important to independent high technology firms to help overcome the disadvantages of the province's peripheral location to the larger North American markets. Both the federal government and the provincial government of Alberta sponsor marketing assistance programs. Although they are available to all firms in general, they are generally designed to assist firms to penetrate distant markets and facilitate the information transfer about potential new ones.

Research Hypothesis 2.12:

That independent high technology firms require or are receiving government assistance for identifying and penetrating new markets.

Most firms (72.1%) indicated that they were seeking to diversify their export market opportunities compared to 26 of 93 firms (27.9%) which were not. A statistically significant cross tabulation between firm ownership and potential export market opportunities was found (Table 7.46). The results showed that while the majority of Canadian subsidiaries (93.3%) and independents (71.4%) were seeking to geographically diversify their export sales, substantially fewer foreign subsidiaries (53.3%) were attempting to do so.

The location of export markets being pursued by Alberta's high technology firms were geographically diverse (Table 7.47). Firms seeking export opportunities in four or more global locations accounted for 45.6% of the respondents, while an additional 29.4% were attempting to market their products or services in at least three locations. Firms which are concentrating their marketing efforts on only one country or region included

TABLE 7.46

CROSS TABULATION OF FIRM OWNERSHIP AND POTENTIAL EXPORT MARKET OPPORTUNITIES

Firm Ownership	Seeking to Geographically Diversify Exports yes	No	% Yes	Row Total
Independents	45	18	71.4	63
Canadian Subsidiaries	14	1	93.3	15
Foreign Subsidiaries	8	7	53.3	15
Column Total	67	26		93

Chi Square = 12.905   Critical chi square at .05 Significance level = 5.99

17 of 68 (25%) of the responses.

These firms cited the United States as the most frequent potential export market (13.25), followed by other provinces in Canada (5.9%), the Pacific Rim (4.4%) and Japan (1.5%).

Although most high technology firms (60%) indicated that they were not receiving any form of government export assistance, a significant 40% were the recipients of marketing support programs sponsored by government (Table 7.48). In fact, 19 of 36 assisted firms (52.8%) received their support from both the federal and Alberta governments. An additional 14 firms (38.9%) made use of programs sponsored by the federal government, while the remaining 8.3% received assistance from the provincial government. A statistically significant cross tabulation of firm ownership by export market assistance revealed that the majority of independents (64.9%) and Canadian subsidiaries (64.2%) received government sponsored export marketing assistance. In contrast, only one foreign subsidiary (9%) indicated that it was receiving assistance which was provided by the federal government (refer to Table 7.49). These results confirm that most independent high technology firms are receiving government assistance for identifying new markets. Hypothesis 2.12 is accepted.

Competition

The nature of the competitive environment is difficult to assess. Many firms have achieved success in the market place by maintaining a competitive technological edge from product performance, while others have avoided direct competition by concentrating on specialized rather than mass markets. In this survey competition was assessed by requesting high technology firms to identify key sources of competition, the number of main competitors, and their perception of the intensity of competition. Analysis of this information will provide an indication of the business environment within which high technology firms in Alberta are competing.

TABLE 7.47

GEOGRAPHICAL LOCATION OF POTENTIAL EXPORT MARKETS

Location	No. of Responses	%
Four or more Global Markets	31	45.6
Three or more Global Markets	20	29.4
United States	9	13.2
Other Provinces in Canada	4	5.9
Pacific Rim	3	4.4
Japan	1	1.5
	68	100.0

TABLE 7.48

EXPORT MARKETING ASSISTANCE

Source of Assistance	No. of Response	%
Provincial Government	3	3.3
Federal Government	14	15.6
Both Governments	19	21.1
No Assistance	54	60.0
	90	100.0

TABLE 7.49

CROSS TABULATION OF FIRM OWNERSHIP BY EXPORT MARKETING ASSISTANCE

Firm Ownership	Government Assistance	No Assistance	Row Total
Independents	24	37	61
Canadian Subsidiaries	9	5	14
Foreign Subsidiaries	1	11	12
Column Total	34	53	87

Chi Square = 16.416 Critical chi square at .05 Significance level = 5.99

TABLE 7.50

SOURCES OF MAIN COMPETITION

Rank	Source of Competition	No. of Responses	% of Firms
1	U.S. Firms	65	72.2
2	Independent Alberta Firms	26	28.8
3	Canadian Subsidiaries	22	24.4
4	Foreign Subsidiaries	19	21.1
5	European Firms	18	20.0
6	Japanese Firms	13	14.4
		163	

N=90

Research Hypothesis 2.13:

That independent high technology firms are entering areas of intense competition rather than identifying a market niche where a headstart could be developed.

Table 7.50 ranks the sources of major competition identified by the respondent firms. American firms (72.2%) were identified most often as the key source of competition by high technology firms in Alberta. Independent Alberta-owned firms were ranked considerably lower (28.8%), followed by Canadian subsidiaries (24.4%), foreign subsidiaries (21.1%), European firms (20%) and Japanese firms (14.4%). Although the reliance on local markets exhibited by the majority of high technology firms in Alberta suggests that import rather than export competition from U.S. firms was of greater concern to the respondents, the 21 export oriented firms (see Market Share, p. 165). clearly identified U.S. firms as the main source of competition in international markets. No significant statistical differences between the responses provided by independent and subsidiary firms were found. However, U.S. firms were cited as the most frequent source of competition by independent firms. Both independent and subsidiary firms generally did not identify each other's groups as key competitors. With respect to the number of firms which constitute key competition, 41.5% of the respondents reported between 1-9 competitors (refer to Table 7.51). Although 27 firms (28.7%) did not know how many companies they were competing against, 12.8% noted between 11-19 competitors and 17% were able to identify in excess of 20 main competitors. Measurement of the intensity of the business environment confirmed that most high technology firms (63.9%) perceived the strength of competition as becoming more intense. Only 3 firms (3.1%) thought the competitive environment was becoming less intense, while 33% perceived no change in the intensity of the competition (refer to Table 7.52). A cross tabulation of firm ownership by the number of firms constituting key competitors and firm ownership by intensity of competition found no statistically significant differences among respondents. Independent firms, Canadian and foreign subsidiaries generally had between 1-9 competitors and all groups perceived a more intensive competitive environment. Hypothesis 2.13 is accepted.

TABLE 7.51

NUMBER OF FIRMS CONSTITUTING KEY COMPETITION

Number of Competitors	No. of Responses	%
1-9	39	41.5
10-19	12	12.8
>20	16	17.0
Don't Know	27	28.7
	94	100.0

TABLE 7.52

INTENSITY OF COMPETITION

Strength of Competition	No. of Responses	%
More Intense	62	63.9
Less Intense	3	3.1
About the Same	32	33.0
	97	100.0

Entrepreneurship

The level of entrepreneurship within a region has proven to be an important factor in contributing to high technology development in many locations. The relationship between entrepreneurial activity and the success of prominent high technology regions such as Silicon Valley and Route 128 in the United States and the Ottawa-Carleton region in Canada has already been demonstrated. However, despite the Alberta government's stated position that the province possesses a strong entrepreneurial base for high technology development, an analysis of entrepreneurial activity and its role in establishing a high technology base has not been explored. To provide greater insight into the level of entrepreneurial activity in Alberta information concerning the background, level and location of education of the entrepreneur(s) and sources of start-up capital were collected and analysed.

Research Hypothesis 2.14:

> That independent high technology firms were founded by technological entrepreneurs who received their academic training and experience outside Alberta

Based on the results of 70 independent high technology respondents, most firms (61.5%) were founded by groups of two or more entrepreneurs (Table 7.53). In total, there were 162 entrepreneurs or an average of 2.3 per firm. Examination of background and experience (Table 7.54) clearly shows that the majority of entrepreneurs were technologically oriented (69.5%). A managerial or administrative background ranked next (21.3%) followed by sales (6.4%) and scientific experience (2.3%).

Most company founders in this survey had completed a university education (71.1%). The largest group held at least a Bachelor's degree (42.3%), while 17.6% completed a Master's degree and 11.2% a Ph.D. An additional 14.8% graduated from a technical or community college. Only 12.7 had some post-secondary training, while 1.4% had no post-secondary training. (Table 7.55).

These results generally compare with Roberts and Wainer's study (1968) of independent high technology firms located along Boston's Route 128. They found that most

TABLE 7.53

NUMBER OF ENTREPRENEURS PER INDEPENDENT FIRM

No. of entrepreneurs	No. of Responses	%
One	27	38.6
Two	27	38.6
Three	9	12.9
Four	5	7.1
Five or more	2	2.8
	70	100.0

TABLE 7.54

BACKGROUND/EXPERIENCE OF ENTREPRENEURS

Background	No. of Responses	%
Technological	98	69.5
Managerial/Administrative	30	21.3
Sales	9	6.2
Scientific	3	2.3
Other	1	.7
	141	100.0

high technology firms were founded by groups of two to five entrepreneurs that were technologically oriented and had completed a university education. However, the level of education among company founders in their sample tended to be higher, the average being a Master's degree in engineering.[16] A significant difference noted among Alberta's founding entrepreneurs relates to the location of academic experience. High technology firms along Route 128 and Silicon Valley were founded by entrepreneurs with strong local academic associations. In Alberta, a slightly higher proportion of the entrepreneurs (56.5%) were found have to received their academic training, and perhaps, much of their experience, outside Alberta. Although more detailed personal data was not obtained, this information implies that a large number of entrepreneurs moved to Alberta during buoyant economic times. In addition, it further suggests that the contribution of Alberta's "home-grown" entrepreneurs to high technology development is less pronounced at present than what is perceived by the provincial government.[17] Hypothesis 2.14 is accepted.

Sources of Start-up Capital

Oakey (1983a) noted that finding start-up capital is an acute problem for new businesses mainly because entrepreneurs lack an established track record with financial institutions on which to base a loan application. These problems have been encountered by Canadian entrepreneurs, who in many cases have felt victimized by what is often perceived to be a very conservative banking system.[18] Coupled with a general lack of private venture capital funds compared to the United States, Canadian entrepreneurs seeking to exploit an innovative idea have experienced frustration in their attempts to raise start-up capital from external sources.

Research Hypothesis 2.15:

> That most high technology entrepreneurs rely on their personal savings as a source of start-up capital rather than external financial sources.

Table 7.56 shows that the majority of independent high technology firms (41%) relied solely on the personal savings of the entrepreneur(s) as their primary source of start-up capital. An additional 22.7% identified a combination of personal savings and bank loans, while 9.1% supplemented their personal savings with private investment capital. Bank loans were the primary source of funds for 10.6% of the respondents, followed by 7.6% which secured private investment. No firms were the recipients of private venture capital funding as a start-up source.

A comparison of the sources of start-up capital by region is shown in Table 7.57. The results indicate that personal savings are the main source of start-up capital in each of the four surveyed regions. Although a wide range of external sources were only generally represented, private venture capital funding provided a significant course of start-up capital (30%) for San Francisco Bay Area firms. This source was only marginally present in the two British regions and was non-existent in Alberta. Despite the recent establishment of Vencap Equities Ltd., a public venture fund and the introduction of the small Business Equity Corporations Program which pools private sources of venture capital, funds from these sources are not expected to provide significant start-up capital for Alberta's entrepreneurs. Instead, it appears that the funds will be used as a source of investment capital for established firms seeking a cash infusion for continued operations, expension, or debt reduction. Hypothesis 2.15 is accepted.

Summary

Examination of the commercial performance of high technology firms in Alberta was conducted to evaluate the strength and viability of these firms in this province. Valuable information concerning the characteristics of Alberta's high technology base was obtained, which has important implications for regional economic development in addition to the future role these firms may play in attempting to diversify the provincial economy.

Although the data suggest that high technology firms are mostly young companies in the early stages of growth, a high technology base is clearly evolving. Financially, revenue and

TABLE 7.55

LEVEL OF EDUCATION OF ENTREPRENEURS

Education Completed	No. of Responses	%
Bachelor's Degree	60	42.3
Master's Degree	25	17.6
Ph.D.	16	11.2
Technical Diploma	21	14.8
Some Post-Secondary Training	18	12.7
No-Post Secondary Training	2	1.4
	142	100.0

TABLE 7.56

SOURCES OF START-UP CAPITAL

Source of Funds	No. of Responses	%
Personal Savings	27	41.0
Personal Savings & Bank Loan	15	22.7
Bank Loan	7	10.6
Personal Savings & Private Investment	6	9.1
Private Investment	5	7.6
Other	3	4.5
Several Sources	3	4.5
Venture Capital	0	0.0
	66	100.0

TABLE 7.57

SOURCES OF START-UP CAPITAL IN HIGH TECHNOLOGY FIRMS BY REGION

Source of Funds	Alberta		Scotland		S.E. England		San Francisco Bay Area	
	No.	%	No.	%	No.	%	No.	%
Personal Savings	48	72.8	20	67.0	11	69	14	52
Previous Assets	0	0.0	0	0.0	2	12	2	7
Bank Loan	7	10.6	2	7.0	1	6	2	7
Venture Capital	0	0.0	1	3.0	1	6	8	30
Other	11	16.6	7	23.0	1	6	2	8
	66	100.0	30	100	16	100	27	100

Note: In the Alberta example those firms which identified a combination of personal savings and other sources were categorized under personal savings only.

Source: Adapted from Oakey (1983a), op cit., p. 24.

profit trends indicate that firms are surviving and growing. Perhaps just as important, executives and managers are generally optimistic about the future financial growth of their firms. The fact that most firms fund their R&D programs internally may be another indication of financial solvency. Although employment data found that only one of every three jobs created during the last five years were professional positions and despite double counting, the total number of jobs generated by high technology firms may indeed exceed that of the agricultural and resource sectors combined.

It is apparent that high technology firms associated R&D with growth in general. While most firms conduct full-time R&D programs, an offensive strategy emphasizing new product/process development was clearly in the forefront. Virtually all firms conducted their R&D internally, with the highest level of external R&D support linkages maintained with private consulting firms rather than government sponsored research facilities. A strong reliance on local markets and a low export propensity was found among the majority of firms. Foreign subsidiaries exhibited the lowest export propensity which suggests that this group lacks a world product mandate. There were, however, examples of independents and Canadian subsidiaries that exhibited a high export propensity. These firms were generally more than ten years old and were primarily in the Electronics and Communications sector. Overall, the importance of generating exports as a means for supporting growth was recognized, with most firms seeking to geographically diversify their market share. However, a more intensive competitive environment was perceived, with firms based in the United States comprising the main competition. With respect to entrepreneurship, most of the founders of independent high technology firms received their academic training from outside the province, perhaps moving to Alberta during buoyant economic times. Risk capital was generally scarce and entrepreneurs relied mainly on personal savings as their primary source of start-up capital. Finally, a comparison of some of the performance indicators analysed here with young high technology firms in other regions has shown that development in Alberta bears a close resemblance to that occurring in Scotland, which also is a peripheral region seeking to establish a high technology base.

D. Location Factors

Diverse locational factors were identified in the literature review which affected firm location. However, several important influences stood out. They were: research parks, proximity to universities, tax climate, labour skills and availability, labour costs, home of the founding entrepreneur and metropolitan locations. Research hypotheses addressing these areas were established to test the locational behaviour of firms. High technology firms were asked to rank a series of 21 factors which may have influenced their location in Alberta on a scale from 'Very Important' to 'Neutral' to 'Not Important'. In addition, firms were asked to rank a list of service linkages important for continuing operations at their present location and to rate Alberta's cities and towns as prospective locations

Research Parks

The introduction of the research park as a regional economic policy tool for aiding and attracting high technology firms has been successful in some regions but unsuccessful in many others. More importantly, examples of emerging high technology regions that show no evidence of geographic clustering suggests that the research park is not an important location factor to high technology firms in Alberta. Analysis of the importance of research parks is critical because the cities of Calgary and Edmonton, in conjunction with the Alberta provincial government are attempting to establish high technology research parks in their respective cities.

Research Hypothesis 3.1:

That high technology firms prefer non-research park locations.

Based on 94 responses, research park locations were unimportant to a firm (34% of responses). Neutral replies however, totalled 37.2% and 12% thought they were slightly important. Only 17% identified research parks to be important or very important locations. A review of the potential advantages of locating in a research park received mixed responses (Table 7.58). While the majority of respondents indicated that such a location would raise a firm's profile, improve communications, stimulate ideas and improve ancillary services, they did not perceive as advantages a more attractive working atmosphere, greater access to university research and an improved sales or profit outlook. Financial cost (36.1%) was cited as the major barrier to relocating into one of the established parks (Table 7.59). If fact, one respondent quoted lease costs in the Edmonton park's "Research Centre 1" facility at more than double his firm's current lease expense. Although several other factors were indicated by the respondents, 'No clear advantages' (13.3%) and 'Present location suitable' (10.9%) were frequent responses. Those firms requiring a location near the 'centre of action' (8.4%) were primarily Calgary-based resource high technology firms whose operations required close proximity to the head offices of oil and gas companies. Hypothesis 3.1 can be accepted.

Labour Skills And Availability vs. University Proximity

The Alberta Government White Paper (1984) places emphasis on universities as a prime location determinant.[19] Although many recent high technology surveys including the Joint Economic Congress study (1982), Glasmeier et al. (1983) and the United States Office of Technology Assessment survey (1984) acknowledge universities as an important location factor, the evidence suggests that labour skills and availability are more important to high technology firms (refer to Table 3.3 in Chapter 3).

Research Hypothesis 3.2:

> That labour skills and availability are more important location influences than proximity to a university or government research facility.

Table 7.60 ranks a series of 21 location factors by percentage of responses very important and important. Labour skills and their supply were regarded as very important or important by 47% of the firms and by an additional 10.5% as slightly important. Only 20% of the respondents thought them unimportant. Proximity to a university was found to be

TABLE 7.58

POTENTIAL RESEARCH PARK LOCATIONAL ADVANTAGES

Potential Advantage	Yes	No	Don't Know	Total	% Yes
Improve Sales or Profits	14	48	33	95	14.7
Raise Company Profile	40	31	23	94	42.6
Improve Communciations	44	27	24	95	46.3
More attractive atmosphere	40	44	11	95	42.1
Greater access to university	29	45	21	95	30.5
Increase Ancillary Services	32	30	33	95	33.7
Stimulate Ideas	43	25	25	93	46.2

TABLE 7.59

FACTORS PREVENTING RESEARCH PARK RELOCATION

Factor	No. of Responses	%
Cost	30	36.1
No Clear Advantages	11	13.3
Present Location Suitable	9	10.9
Need to be Near Centre of Action	7	8.4
Currently Own premises	4	4.8
Not Enough Space	4	4.8
Presently Located in Research Park	4	4.8
Other	14	16.9
	83	100.0

TABLE 7.60

LOCATION FACTORS

Rank	Factor	% Very Significant & Significant
1.	Overall Business Climate	77.9%
2.	Founding Entrepreneur Lived There	67.4%
3.	Access to Markets	60.4%
4.	Labour Skills/Availability	47.4%
5.	Political Stability	45.8%
6.	Provincial Tax Climate	40.0%
7.	Local Government Incentives	30.6%
8.	Proximity to International Airport	27.4%
9.	Proximity to Domestic Airport	25.3%
10.	Proximity to University	21.3%
11.	Provincial Gov't. Support Programs	21.1%
12.	Availability of Venture Capital	17.1%
13.	Recreational Opportunities	16.8%
14.	Local Transportation	16.0%
15.	Access to Raw Materials	15.1%
16.	Energy Costs/Availability	14.9%
17.	Cost of Living	14.7%
18.	Cultural Amenities	14.7%
19.	Labour Costs	14.0%
20.	Proximity to Gov't. Depts./Offices	12.6%
21	Climate	6.3%

unimportant by 40.4% of the respondent firms. In contrast, only 21.3% considered it important or very important. The relatively low ranking of proximity to a university was surprising given the frequency of use of external R&D university facilities by high technology firms (Table 7.32 p. 150). Although these results appear to be contradictory, they may suggest that external R&D linkages with universities are generally informal contacts, and therefore, less important as a locational influence on most firms. Nevertheless, labour skills and availability were clearly priorized as a more essential factor than proximity to a university. Hypothesis 3.2 is accepted.

Labour Costs

Research Hypothesis 3.3:

That the cost of labour is an important locational influence.

Labour costs ranked 19th out of the 21 location factors tested in this survey. While only 14% perceived than important, a high 46.2% of the responses were neutral. Thirty per cent thought labour costs were unimportant. Because most firms are small in numbers of employees, and are almost entirely non-union, labour costs can be built into high value products and services. These findings account for the low level of importance attached to them. Hypothesis 3.3 is not accepted.

Provincial Tax Climate

Research Hypothesis 3.4:

That tax climate is an important locational influence.

An advantageous provincial tax climate was considered important or very important by 40% of the respondents. However, the overall business climate, which would also include federal taxes and incentives was the highest regarded location factor with 77.9% responding that it was important or very important. Federal government tax incentives received high praise (72% of responses) and grants were also found to be important (57.3%). Regarding provincial tax incentives for R&D, 65.4% thought they were satisfactory or very satisfactory. This level of response was surprising because the Alberta provincial government does not offer tax credits for R&D. However, it may suggest that the introduction of provincial R&D tax credits would contribute to the improvement of the overall business climate and that most firms in general perceive tax credits as a positive business influence. With respect to provincial grants, 53.8% identified them as satisfactory or very satisfactory. In addition, the provincial corporate tax rate remains the lowest in Canada (11%), which in some instances can be lowered to 5% (Small Business Deduction) or even 0% if engaged in manufacturing. It should be noted here that two other factors in this context were also highly regarded. Political stability, which relates to continuity of provincial government business policy and therefore contributes to the overall business climate, was considered by 45.8% of the respondent firms to be very important or important. Indeed, political stability is an advantage Alberta has enjoyed when compared with the other western provinces. In fact, it ranked ahead of Provincial Tax Climate as did Access to Markets (60.4% very important or important). The strong reliance on local markets (refer to Market Share, p. 164) indicates that the potential of local markets was an important locational factor which stimulated firm development in Alberta. Thus, it is not surprising to find that most high technology firms (59.1%) obtain greater than 50% of their purchase inputs from inside Alberta. Similarly, most firms (59.2%) sell greater than 50% of their production output inside Alberta. A strong preference for carrying out business with local suppliers was indicated with 92.1% of the respondent firms expressing an interest in purchasing more of their inputs locally, if available. The strong business ties in Alberta may also be responsible for the relatively low importance placed on proximity to international airports (27.4%). However, with the majority of firms seeking to establish or diversify their export base, proximity to an international airport may become a more important locational influence over time.

In summary, the importance placed on the overall business climate is in part reflected by the high regard for political stability, access to local markets and tax climate. Although these factors all ranked ahead of Provincial Tax Climate, it was considered to be an important influence. Hypothesis 3.4 is accepted.

Home of the Founding Entrepreneur

Research Hypothesis 3.5:

> That home of the founding entrepreneur often explains location.

"Founding Entrepreneur Lived There" was found to be the second most important location influence with 67.4% of the respondents identifying it as very important or important. While this factor may seem an obvious point, it focusses attention on the personal preferences of executives in choosing a location and stresses strong local association with the present community. The importance of entrepreneurial preference on location was strongly evident during an interview with the Vice-President of a high technology firm which imported 50% of its purchase inputs from outside Alberta, while exporting 100% of its output to markets outside the province:

> "There is really no justification for our firm to be located here..... It just happened to be that the four founding partners were all from Edmonton and we like it here."

Hypothesis 3.5 can be accepted.

Metropolitan Locations

Research Hypothesis 3.6

> That metropolitan location will be preferred rather than regional cities or small towns because of the availability of services.

The cities of Calgary and Edmonton are the two largest urban centres in Alberta. In fact, their combined population comprises slightly more than 50% of the provincial total of 2,348,000 people[20]. Thus, it is not surprising to find that 91.9% of the high technology respondents were located in Calgary and Edmonton, with towns in their commutersheds accounting for most of the remaining 8.1%. The concentration of firms in metropolitan cities and their immediate region raises the question of whether these firms could operate satisfactorily elsewhere in Alberta. This question is important from a regional economic development perspective because it will help address the issue of "footlooseness" among high technology firms as well as the relative attractiveness of other cities and towns in Alberta. High technology respondents were asked which other urban communities in the province (population greater than 5,000) might be satisfactory as a location for their firm (refer to Table 7.61). Although the results are subjective and not based on detailed economic assessments, the personal preferences of executives in choosing a location remains an important consideration.

One-half of the firms responded that they could operate in other locations in Alberta, but 41.8% could not do so and 8.2% did not know. While these results might appear encouraging, Calgary or Edmonton were clearly the preferred locations. St. Albert, a city in Edmonton's commutershed ranked third, followed by the City of Leduc, which is located adjacent to Edmonton International Airport. The City of Red Deer was the only regional location outside a commutershed which received any preference, but it was considerably lower than Calgary and Edmonton.

Metropolitan cities and their immediate region were the most attractive locations for high technology firms in Alberta not least because of the supporting services which are available in such large cities, in particular, financial, engineering, computer and data processing, transportation and government R&D facilities (Table 7.63). The metropolitan location of these services is a reasonable assumption even though a locational breakdown by city and town was not conducted for purchases and sales. Moreover, it is recognized that the level of support services is largely dependent on the market for these services, which indirectly relates to city

TABLE 7.61

RATING OF ABILITY OF ALBERTA'S CITIES & TOWNS TO SATISFY HIGH TECHNOLOGY FIRMS' LOCATIONAL REQUIREMENTS

Rank	City/Town	No. Responses	% Very Satis/ Satisfactory	% Neutral	% Unsatis/ Very Unsatis.
1.	Calgary	98	92.9	3.1	4.1
2.	Edmonton	97	76.3	13.7	10.3
3.	St. Albert	96	31.3	17.7	51.0
4.	Red Deer	96	20.8	30.2	49.0
5.	Leduc	96	20.8	25.0	54.2
6.	Airdrie	96	17.7	24.0	58.3
7.	Fort Saskatchewan	96	16.7	25.0	58.4
8.	Spruce Grove	95	15.8	24.2	60.0
9.	Stony Plain	96	14.6	21.9	63.6
10.	Lethbridge	95	12.6	22.1	65.3
11.	Medicine Hat	95	8.4	16.8	74.8
12.	Lloydminster	96	7.3	21.9	70.8
13.	Fort MacMurray	95	6.3	14.7	78.9
14.	Wetaskiwin	96	5.2	21.8	73.0
15.	Grande Prairie	96	4.2	13.5	82.3
16.	Drumheller	95	4.2	13.7	82.1
17.	Brooks	96	4.1	12.5	83.3
18.	Camrose	96	4.1	16.7	79.2
19.	Hinton	96	3.1	10.4	86.5
20.	Edson	96	3.1	11.5	85.4
21.	Peace River	96	2.1	14.6	83.4
22.	Crowsnest Pass	96	1.0	13.5	85.4

TABLE 7.62

SERVICE LINKAGES

Rank	Factor	% Very Significant & Significant
1.	Financial Services	40.4%
2.	Engineering	37.2%
3.	Computer & Data Processing	34.0%
4.	Transportation	28.0%
5.	Government R&D Laboratories	27.6%
6.	Office & Lab Rentals	24.5%
7.	Information Banks	23.4%
8.	Commercial Test	22.3%
9.	Legal Services	21.1%
10.	Private R&D Laboratories	19.4%
11.	Advertising	19.1%
12.	R&D Parks	17.0%
13.	Innovation Centres	15.9%
14.	Insurance	13.7%
15.	Management Consulting	11.8%
16.	Office Overload	5.3%

size. Smaller communities are unlikely to be able to compete with larger urban areas which suggests that these services are more likely to be found in the larger metropolitan areas. A comparison of the service linkages important to firms in smaller communities would not be a worthwhile exercise because virtually all the respondent firms were located in or close proximity to Calgary and Edmonton. It should be noted however, that Bednarz (1984) in his study of high technology firms in Texas, found that firms were generally more concerned with material (backward) linkages to suppliers and market (forward) linkages to buyers than they were with the availability of support services. Support services were generally unimportant, perhaps because most high technology firms in smaller communities were small in size and did not generate any appreciable demand for locally-based support services. Nevertheless, the problem of securing financial services, which are more readily available in larger metropolitan areas, was identified as a significant problem. Similarly, most high technology firms were found in Texas' larger metropolitan centres which included Houston, Dallas-Fort Worth, San Antonio and El Paso. Hypothesis 3.6 can be accepted.

Summary

Analysis of location factors has demonstrated that the research park is not important to Alberta's high technology firms. However, most firms indicated that such a location would raise a firm's profile, improve communications, stimulate ideas and improve ancillary services. Financial cost was cited as the major barrier to relocating into the Calgary or Edmonton parks.

Location factors important to high technology firms were ranked in the following order: Overall business Climate, Founding Entrepreneur Lived There, Access to Markets, Labour Skills/Availability, Political Stability and Provincial Tax Climate. Proximity to University labour costs and proximity to International Airport, three factors found to be important to high technology firms in other regions, were not important to Alberta's high technology firms. Although 50% of the firms indicated they could successfully operate in other locations in the province, Calgary and Edmonton were clearly the preferred locations. The City of Red Deer was the only regional location outside the Calgary and Edmonton metropolitan areas which received any preference. Support services identified as important to business operations included financial, engineering, computer and data processing, transportation and government R&D facilities. These services are more readily available in the Calgary and Edmonton metropolitan areas, where most firms were founded and presently located.

E. Government Support Programs

The literature review has shown that all levels of government in Canada and the United States have been pursuing high technology as an economic development alternative. Although these efforts have led to the introduction of numerous policy initiatives and programs, encouragement of R&D through government incentives has prevailed as perhaps the most common form of government support. In Alberta, it has only been very recent that high technology development has been formally addressed by the provincial government. Although the White Paper (1984) and Discussion Paper (1984) are exploring new policy alternatives, the importance of existing programs warrants attention. Examination of government support programs is particularly important at this time given the provincial government's planned efforts to encourage high technology development.

Research and Development Incentives

The federal government administers both tax credit and financial grant programs for the encouragement of industrial R&D tax credit program, but it does provide grants for R&D.

Research Hypothesis 4.1:

> That independent high technology firms prefer financial grants to fund R&D programs as opposed to tax credits.

4.2:

> That subsidiary firms prefer tax incentives for R&D funding as opposed to financial

grants.

Table 7.63 provides a rating of government R&D incentives by the respondents. Although its information was briefly highlighted earlier in this chapter, the majority of firms generally agreed that government incentives were very important/important to their R&D efforts, although federal incentives received higher praise. Overall, tax credits were considered more important than financial grants.

The rating of government R&D incentives for firm ownership (Table 7.64) indicates that most independent firms thought R&D tax credits were more important than financial grants. In contrast, Canadian subsidiaries gave equal weight to the importance of tax credits and grants, although federal incentives received stronger attention. Foreign subsidiaries assigned the lowest level of importance to R&D incentives, but tax credits were generally rated higher than grants.

The high level of importance attributed to R&D tax credits by independent firms suggests they are generating sufficient cash flow to use the credits to reduce taxable income. A preference for tax credits to encourage R&D rather than financial grants was further reflected by the comments received concerning R&D incentives:

> "The current government environment consists literally of hundreds of grant programs. The curent process is very time consuming for small management team. We believe a simplified system of tax credits or tax incentives would be more efficient for both industry and government"

> "We believe the government should provide lucrative tax breaks for R&D but grants should abolished. Reasons are tax breaks only benefit profitable, well-run companies ......"

This survey was conducted at the time the federal government announced the cancellation of the Science and Research Tax Credit Program (SRTC). It evoked the following response from one firm:

> "The federal budget last week effectively stonewalled $2 million dollars of investment in my company's R&D programs --- Result, 6 permanent jobs will not be created. The S.R.T.C. was an invaluable investment tool. One project could be Alberta's future".

TABLE 7.63

RATING OF GOVERNMENT R&D INCENTIVES

Type of Incentive	% Very Important/Important	% Neutral	% Slightly/Not Important
Federal Tax Credits	72.0	8.5	19.5
Federal Grants	57.3	7.3	35.4
Provincial Tax Credits *	65.4	12.3	22.2
Provincial Grants	53.8	12.5	33.7

*The Alberta government does not administer an R&D tax credit program

TABLE 7.64
FIRM OWNERSHIP RATING OF GOVERNMENT R&D INCENTIVES
(% Very Important/Important)

Firm Ownership	Federal Tax credits	Federal Grants	Provincial Tax Credits	Provincial Grants
Independents	81.5	64.8	72.2	59.2
Canadian Subsidiaries	75.0 (60.5)	75.0 (52.5)	58.3 (58.3)	58.3 (47.3)
Foreign Subsidiaries	46.1	30.0	58.3	36.3

Note: Bracketed figures represent mean response for subsidiary firms.

Only one firm recognized that Alberta does not administer a provincial R&D tax credit program. The respondent circled the question and provided the following comment:

> "What grants and incentives? The province should be encouraging R&D".

Based on these results, hypothesis 4.1 is not accepted, but hypothesis 4.2 is accepted.

Financial Assistance to Relocate in Alberta

The province of Alberta experienced rapid growth in revenues as a result of the recent oil and gas "boom" period. As a long-term strategy to provide investment capital and income or the Alberta economy, the provincial government created the Heritage Savings Trust Fund in 1976. With total capital estimated at $14 billion, it is a unique provincial capital resource in Canada which has allowed the government to focus attention on economic development alternatives, which includes high technology.

Research Hypothesis 4.3

> That provincial government financial assistance has served to attract high technology firms to locate in Alberta.

Firms which relocated to Alberta from centres outside the province accounted for 6 of 93 respondents (6.4%). Four firms transferred their operations from Eastern Canada (east of Manitoba), while one each relocated from Western Canada (excluding Alberta) and a foreign country (excluding U.S.A.) Only one firm was found to receive financial assistance from the provincial government as an incentive to relocate here. It is not known if any high technology firms left Alberta to relocate elsewhere, although one independent firm noted "the possibility of leaving Alberta is also being discussed". Hypothesis 4.3 is not accepted in the context of this study. Given time, firms may be attracted from elsewhere, a subject which could be tested in a later study.

Provincial Government Support Programs

The provincial government White Paper (1984) highlights several economic development programs initiated since 1972. However, it remains unclear as to the number of high technology firms that make use of support programs and how important they are in providing assistance. Moreover, because the White Paper identifies a series of policy alternatives, the general views of high technology firms toward the proposed industrial and science strategy have important implications.

Research Hypothesis 4.4:

> That provincial government support programs are more important to subsidiary firms than independents.

Provincial government support programs were not important for 40% of the respondents and only slightly important for an additional 14.7%. A cross tabulation of firm ownership by provincial government support programs found of statistically significant differences among responses and existing programs were not considered important by any of the firm groups. Only 20% of the Canadian subsidiaries thought provincial government support programs were very important/important, followed by 17.4% of the independents and 7.1% of the foreign subsidiaries. It should be noted however, that 46.8% of the firms made use of existing support programs. Market support(31.4%), the programs and services provided by the Alberta Research Council (25.7%) and manpower programs (14.3%) were the support areas most frequently cited by the respondents.

The low level of importance attributed to provincial government support programs by most firms may suggest that existing programs are not meeting the needs of high technology companies. Although firms were asked to identify other measures which could be initiated by government, the question was not well answered with only 35 firms responding. Numerous areas were mentioned, but a general commitment by the provincial government toward high technology (which would include programs targeted specifically to high technology) received the strongest attention (37.1%), followed by greater R&D support (31.4%), free trade (11.4%)

and a more positive oil environment (8.6%). Comments received from various companies were generally critical of existing programs:

> "Government support programs, in the end, seem to put a company through the same wringer as the banks or private investors. Given a choice I would prefer to deal with the banks."

> "Unfortunately the attitude of the Alberta Government is not towards investment in risk ventures. e.g. Vencap"

> "Some government programs are too restrictive for new leading edge companies to neatly fit into ......"

The reaction by Alberta's high technology firms toward the provincial government White Paper and its proposals for high technology support was mixed (Table 7.65). It is interesting to note that the executive and management personnel in most firms (52.8%) had not reviewed the White Paper. Although a significantly larger proportion of firms (40.0%) thought the proposed strategy would contribute to high technology growth in the province, 43.6% did not know. Finally, 48.9% of the respondents felt that support in the policy areas identified by the White Paper would assist their firms, but 46.7% did not. Despite the generally negative attitude toward the importance of provincial government support programs and the mixed response received concerning the recently published White Paper, 38.2% of the respondents cited the provincial government as the most appropriate level of government for program support (Table 7.66). An additional 23.6% thought the combined efforts of the federal and provincial governments were necessary, while 20.2% felt that program support should come mainly from the federal government. Only one firm (1.1%) identified municipal government as the most suitable and 3.4% indicated that all levels of government were important in the provision of support programs. It is interesting to note that a conservative business group (13.5% of responses) thought that government should not be providing any form of support.

In summary, these results suggest that most high technology firms do not perceive existing provincial government support programs as important to their operations, although a significant proportion of the respondents make use of them and believe further that the

TABLE 7.65

HIGH TECHNOLOGY FIRMS' REACTION TO THE PROVINCIAL GOVERNMENT WHITE PAPER

Observation	No. Responses	Yes	No	Don't Know	% Yes
Reviewed White Paper	93	44	49		47.2
Will Contribute to High-Tech Growth	55	22	9	24	40.0
Will Assist Your Firm	45	22	21	2	48.9

TABLE 7.66
APPROPRIATE LEVEL OF GOVERNMENT FOR SUPPORT PROGRAMS

Level of Government	No. of Responses	%
Provincial	34	38.2
Provincial & Federal	21	23.6
Federal	18	20.2
Municipal	1	1.1
All Levels of Government	3	3.4
No Level of Government	12	13.5
	89	100.0

province is the most appropriate level of government to provide them. If the results of the Canadian and foreign subsidiary groups are examined separately, hypothesis 4.4 can be accepted. If combined, provincial government support programs would be more important to independent firms and hypothesis 4.4 could not be accepted.

Local Government High Technology Program

Research Hypothesis 4.5:

> That to date local government high technology programs have not played an important role in attracting high technology firms

Among location factors, local government incentives ranked seventh with 30.6% of the responses being very important or important. However, 46.3% perceived them to be slightly important or not important. Many communities in Alberta have established economic development agencies for the purpose of promoting their localities to prospective firms seeking to relocate or expand operations. In most cases, industries are sought to strengthen the financial base of the community, but with the higher levels of unemployment experienced in recent years, job creation has commanded greater attention. Marketing brochures and community profiles which in most cases emphasize cultural amenities, local facilities and recreational opportunities are often prepared and circulated to prospective clients. Unfortunately these factors do not resemble what high technology firms say are important (Table 7.60). As Bednarz (1984) points out, local groups in general,

> "seem to have a stereo typical picture of high-tech industry as one which is relatively small scale, produces high-valued compact products, employs professionally and technically skilled people and is clean and light ..... While it is true that some technology firms do fit this model, many others do not."[21]

This conception of high technology firms suggests that if communities in Alberta hope to attract them, greater emphasis on adopting local strategies that address what they have to offer to prospective firms is required. However, the low rating given to non-metropolitan locations by Alberta's high technology firms confirms that local strategies directed at attracting firms to smaller cities and towns will not be an easy task. Any proposed strategies would require a patient long-range approach that concentrates on industrial requirements. Even then there is no guarantee of success. The provincial government White Paper, which proposes a framework for the encouragement of high technology development, emphasizes a science and technology infrastructure, but offers little direction for local governments. The result has been intensive competition between the cities of Calgary and Edmonton for provincially sponsored research facilities, rather than targeting support based on each city's high technology strengths. It is worth noting here that although Steed and DeGenova (1983) found that Ottawa's high technology firms could successfully operate out of several cities across Canada, Calgary, and more notably Edmonton, were not rated highly. While their sample does not represent a cross-section of high technology firms across Canada, the findings suggest that provincial support and cooperation with local governments in implementing high technology development programs will be important. Hypothesis 4.5 is accepted.

Summary

Analysis of government support programs has shown Federal Tax incentives, more specifically R&D tax credits, are important to the R&D efforts of high technology firms, overall, tax credits were preferred to financial grants.

Although it is clear that provincial government support programs are not important to most high technology firms, just under one-half of the respondents still made use of them. Market support, the programs and services provided by the Alberta Research Council and manpower programs, were the support areas most frequently cited. Provincial government financial assistance has not succeeded in attracting high technology firms to locate in Alberta and only one firm was found to receive funds as an incentive to relocate here. Reaction to the proposals by the government's White program was mixed. Most firms had not reviwed the document and did not know whether it would contribute to high technology growth in the province. Of those firms which did review the White Paper, approximately one-half felt that there were proposals in it which would assist their firm. Finally, on the local level, most communities in Alberta have not prepared or implemented comprehensive high technology development programs confirming that local development initiatives have not played an important role in attracting or supporting high technology firms.

TABLE 7.67

Summary of Research Hypotheses

AREA OF RESEARCH		RESEARCH HYPOTHESIS	RESULTS
A. Categorization of High Technology Firms.	1.1	That high technology in Alberta is associated predominantly with resource-based and service oriented firms than with the stereo-typical computer, semi-conductor and electronics manufacturing firms.	Not Accepted
	1.2	That most medium-size and large high technology firms in Alberta are subsidiaries of Canadian and foreign-owned firms headquartered outside Alberta as opposed to independent Alberta-owned companies which are small in size	Accepted
	1.3	That most independent firms started by entrepreneurs are young in age, that is, less than five years old, as opposed to most subsidiary firms which were established more than ten years ago. In addition, most independents have not established subsidiaries elsewhere.	Partially Accepted
B. Commercial Performance of of High Technology Firms	2.1	That gross revenue and net profit performance among high technology firms is greater in independent firms than Canadian and foreign controlleld subsidiaries.	Accepted
	2.2	That high technology sectors exhibit a wide variety of experiences in gross revenue and net profit growth	Accepted

AREA OF RESEARCH		RESEARCH HYPOTHESIS	RESULTS
	2.3	That high technology firms directly associated with Alberta's resource industries have been generally more successful than others	Not Accepted
	2.4	That most Canadian and Foreign controlled subsidiaries carry out their R&D programs outside Alberta	Not Accepted
	2.5	That most small high technology firms conduct part-time R&D programs compared to medium-sized and large high technology firms which carry out full-time R&D, and that most high technology firms prepare an R&D budget.	Partially Accepted
	2.6	That investment in R&D is focused on adaptations of existing products and processes rather than new product/process development	Not Accepted
	2.7	That R&D programs carried out by independent high technology firms are primarily contracted to external groups and agencies	Not Accepted
	2.8	That R&D programs carried out by independent high technology firms are funded primarily by Federal and provincial government assistance programs.	Not Accepted
	2.9	That high technology firms have not created much direct employment in Alberta	Not Accepted
	2.10	That new high technology employment created has been largely in routine, low skilled, low paying non-professional positions as opposed to highly skilled, high paying professional and technical employment	Accepted

AREA OF RESEARCH		RESEARCH HYPOTHESIS	RESULTS
	2.11	That high technology firms generate most of their sales in Alberta before achieving significant expert sales to the United States and other foreign markets.	Accepted
	2.12	That independent high technology firms require or are receiving government assistance for identifying and penetrating new markets.	Accepted
	2.13	That independent high technology firms are entering areas of intense competition rather than identifying a market niche where a headstart could be developed.	Accepted
	2.14	That independent high technology firms were founded by technoloogical entrepreneurs who received their academic training and experience outside Alberta.	Accepted
	2.15	That most high technology entrepreneurs rely on their personal savings as a source of start-up capital rather than external financial sources	Accepted
C. Location Factors	3.1	That high technology firms prefer non-research park locations.	Accepted
	3.2	That labour skills and availability are more important location influences than proximity to a university of government research facility	Accepted
	3.3	That the cost of labour is an important locational influence	Not Accepted
	3.4	That tax climate is an important locational influence	Accepted

AREA OF RESEARCH		RESEARCH HYPOTHESIS	RESULTS
	3.5	That home of the founding entrepreneur often explains location	Accepted
	3.6	That metropolitan location will be preferred rather than regional cities or small towns because of the availability of services	Accepted
D. Government support Programs Programs	4.1	That independent high technology firms prefer financial grants to fund R&D programs as opposed to tax credits.	Not Accepted
	4.2	That subsidiary firms prefer tax incentives forR &D funding as opposed to financial grants.	Accepted
	4.3	That provincial government financial assistance has served to attract high technology firms to locate in Alberta	Not Accepted
	4.4	That provincial government support programs are more important to subsidiary firms than independents	Accepted
	4.5	That to date local development high technology programs have not played an iportant role in attracting high technology firms.	Accepted

Endnotes: Chapter VII: High Technology Questionnaire Survey: Results and Analysis

1. S.I.C. codes are used by both Canadian and U.S. Agencies. It should be noted, however, that coding groups vary in each country.

2. Bollinger, op. cit., pp. 4-5.

3. Litvak & Maule (1980), op. cit., p. 78.

4. Steed, op. cit., pp. 64-65.

5. Oakey (1983a), op. cit., pp. 4-5.

6. Ibid., p. 7.

7. Brown (1983b), op. cit., p. 20.

8. Steed, op. cit., pp. 66.

9. Oakey (1983a) op. cit., p. 19.

10. Ibid., p. 27.

11. Browne (1983b), op. cit., p. 25.

12. Weiss, op. cit., p. 54.

13. Ibid., pp. 84-85.

14. Steed & DeGenova, op. cit., pp. 273-274.

15. Litvak & Maule (1980), op. cit., pp. 75-78.

16. Roberts & Wainer, op. cit., pp. 79-83.

17. See Alberta Government "White Paper", op. cit., p. 55. Under the heading STRENGTHS, item No. 5.

18. See Litvak & Maule (1980).

19. Alberta Government "White Paper", op. cit., p. 45.

20. Alberta Bureau of Statistics (1985), op. cit., p. 17.

21. Bednarz, op. cit., p. 13.

VIII. Conclusions and Policy Implications

A. Conclusions

In this thesis, an attempt has been made to gain insight into Alberta's high technology base. These findings have important implications in terms of the contribution which high technology firms may make to the overall diversification of the provincial economy. The data collected and analysed from the high technology questionnaire survey has provided valuable information about the structure, commercial performance, locational requirements and government support programs important to existing firms, but more importantly, it has demonstrated that a high technology base is evolving. Table 7.67 provides a summary statement of the results arising from the testing of hypotheses. A general discussion of the results follows.

Alberta's high technology sector is generally immature. Most firms are small independently-owned Alberta companies which are privately held. Larger firms with more than 100 employees are considerably fewer and are comprised mainly of Canadian or foreign-owned subsidiaries. Although most firms were established more than six years ago, just over one-third were founded during the last five years and a majority during the last ten years. This finding clearly demonstrates that the recent economic recession has not hampered high technology firm development in the province. However, it also reflects in the sample and the total population of firms. Most subsidiary firms were more than ten years old, while the largest proportion of younger technology firms were independents.

Alberta's high technology firms are manufacturing products predominantly in the electonics and communications, and computer areas, but a large proportion of them sell specialized services. Firms in the petroleum, agricultural and biomedical sectors were also represented, but to a much lesser degree. Nevertheless, a heterogeneous sample was found. While analysis of product or service produced suggests that a diversification process is occurring, it is cautioned that dependence on doing business with the petroleum industry was not fully ascertained. On the one hand the strong reliance on local markets may suggest dependence on the petroleum industry for business, but on the other it may indicate an immature sector of firms that must succeed in local markets before venturing into domestic and international markets located far from the home-base. The fact that those firms prominent in international markets were generally more than ten years old supports the latter of the two arguments. Moreover, geographic diversification was found to be important with just under one-half of the firms establishing subsidiaries in three main areas; Alberta, the United States and Eastern Canada (east of Manitoba) in that order.

Analysis of financial trends found that high technology firms are surviving and growing. In addition, corporate executives and management were generally optimistic about the future potential for their firms' growth. It is apparent that high technology firms associated R&D with growth in general. Most firms were found to conduct full-time, internal R&D programs, which emphasized new product/process development. A regional comparison of firms found that this trend was not only evident in Alberta, but also in the organizational structure of firms in Scotland, South East England and the San Francisco Bay Area. This level of internal R&D commitment was confirmed by the casual nature of external R&D contacts which provided mainly a supportive role. The reliance primarily on private consultants for external R&D support is perhaps due to a generally conservative business community. However, it should be noted that it has only been very recently that the provincial government has embarked upon a program of establishing a scientific infrastructure that includes public-sponsored R&D facilities. The Alberta Microelectronics Test Centre, for example, only opened its doors for business this past year and it has not yet been decided where the proposed provincial innovation centre will be located. R&D programs were funded primarily from internally generated cash flow indicating thatmost high technology firms moved forward incrementally using their retained earnings for ongoing R&D needs. Significantly however, 41.1% of the respondents received some form of financial assistance for R&D from government sources. Greater reliance and importance was attached to federally sponsored programs despite the province of Alberta's claim that it spends more money on R&D than any other province in the country. Recent statistics show that the provincial government R&D funding is directed mainly at non-renewable energy and fuels research (51.6%) compared to 16.3% for health and social development, 10.9% for industrial and economic development, 9.7% for agriculture and 6.1% for the advancement of science.[1] Federal R&D funding for non-energy related sectors in Alberta is considerably higher.[2] Thus, expenditures on energy research account for the high level of total provincial government funding which conversely explains the higher praise for federal R&D funding noted by high technology firms.

A young high technology base is further reflected in the size of the labour force among respondent firms. Four large firms, two Canadian subsidiaries, one foreign subsidiary and a Crown corporation accounted for 74.2% of employment. Although a strong imbalance between large and small firm employment size was noted, 3 out of 4 high technology firms created jobs between 1980-1984. This finding is encouraging to a province seeking to diversify away from traditional resource areas. Of greater concern however, is the type of jobs being created. Two of every three positions created were non-professional, low-paying jobs and not the type of high-paying professional and technical positions often associated with high technology employment. Weiss (1985) (in Hall & Markusen) refers to this characteristic as the "vanishing middle" nothing that if a more equitable employment structure is not attained, economic chaos and not salvation will result.[3]

Marketing was a key area identified by high technology firms. Most firms are attempting to diversify their market share by penetrating international markets and a large proportion of them have sought assistance from the provincial and federal government to help overcome the disadvantages of a peripheral location. Success in diversifying market share beyond the small local market is essential for high technology firm growth in Alberta. Clearly, independent firms and domestic subsidiaries were more successful in achieving international export sales as compared to foreign subsidiaries which lacked a world product mandate. Most firms perceived a more intense competitive environment and identified American firms as the main source of competition in both local and international markets.

An analysis of Alberta's high technology entrepreneurs has shown that most are technologically oriented and have at least a Bachelor's degree from a recognized university. However, slightly more than one-half obtained their education from academic institutions located outside Alberta. While it is not clear whether these entrepreneurs were originally from Alberta and sought education outside the province or were from locations elsewhere, moving to Alberta during buoyant economic times, most firms were founded during the last ten years which were characterized by strong in-migration as a result of the petroleum "boom". This finding supports the latter argument. Entrepreneurs relied mainly on their personal savings as the main source of start-up capital. External sources of capital were comprised mainly of institutional bank funding and private investment capital. On a regional basis it is worth noting that banks in Alberta and Scotland, two peripheral regions, appeared to be more involved in providing funds for small high technology firms than their counterparts in South East England and the San Francisco Bay Area. However, venture capital was absent in Alberta with no firms reporting it as a source of start-up capital. The provincial government has attempted to address this problem with the establishment of Vencap Equities Ltd., a public sponsored venture capital investment fund and the Small Business Equity Corporation Program which provides incentives for privately pooled venture capital companies.

Research parks were unimportant influences on location with the cost barrier being cited as the major reason. Another important reason not mentioned in this context is that of the location of the founding entrepreneur and the age of the firm. In most cases the two research parks did not exist when firms were established. For approximately two-thirds of the firms, "home of the founding entrepreneur" was an important location factor. It is likely that if Alberta's high technology firms become larger, the cost factor may be overcome and relocations to them may occur. At present only one major firm and a few small independents have located in the Edmonton Research and Development Park. Research Centre 1, a tenant facility, exists in the park and discussion with one prominent firm which relocated there revealed their overall satisfaction with the site and services provided by the Research Park

Authority. The Calgary Research and Development Park has not progressed to the development stage, but construction of multi-tenant research and development facilities are planned.

Labour costs are not regarded as significant because firms are small in numbers of employees and can be built into high value products and services. However, the availability of labour skills was regarded as very important though no hiring difficulties were experienced by most firms. For 27.4% of firms which had such difficulties, the lack of skilled personnel was the main problem. It would seem that the weakness of proximity to a university is because of the size of firms and their needs relating to developmental work on products and marketing, coupled with the traditional university focus on basic research. There is, however, greater evidence of university interaction with the business community with leading edge companies like Chembiomed Ltd. and Majestic Lasers Ltd. participating in joint research efforts with the University of Alberta. Proximity to airports, another important location factor derived from the literature review, was also not found to be important to Alberta's high technology firms. This finding relates to the strong reliance on local markets which suggests that airport proximity may become more important to firms which achieve success in international markets.

Clearly, the political stability and excellent business climate offered by Alberta including its low provincial taxes, was found to be highly important. Without a good overall business climate provided by the provincial and federal governments, new small technology firms would find it more difficult to survive. With respect to location, most firms have been founded in the two large cities of Edmonton and Calgary where skilled labour and specialized services are available. From a regional development perspective, it is not encouraging that most firms felt they could not operate successfully outside the Edmonton and Calgary regions. Red Deer, a large regional city in the Edmonton-Calgary corridor was the only centre outside a metropolitan region that received any preference. While it might be possible for some accessible regional cities to eventually add high technology firms to their economic base, smaller, rural communities throughout the province are at a disadvantage. Engineering, computer and data processing, transportation and most important financial services are vital to continuing operations and these services are not readily available in smaller communities.

It is important to note that Alberta's small high technology base has evolved primarily as a result of entrepreneurial initiative rather than any explicit government policies, although political stability and a favourable tax climate have contributed to a supportive business climate in general. However, government programs, with the exception of research and development initiatives and marketing programs are not important to high technology firms. In addition, federal government incentives were regarded as more important than provincial government programs even though the provincial government was identified as the most appropriate level of government for support. The provincial government's approach to high technology, until the recent publication of the White Paper, has been ad hoc with programs grouped into economic development initiatives in general. However, it is worth noting here that in the more prosperous and innovative South East England and San Francisco Bay Areas, it was found also that government support programs were largely ineffective.[4] For high technology to grow and prosper in Alberta most firms felt the provincial government should provide a stronger commitment to high technology development, in addition to greater financial support for R&D. These measures are addressed in part by the provincial government White Paper, which received a mixed response from the respondent firms. Less than one-half of the Corporate executives and management had reviewed the White Paper, which implies that private sector participation in the preparation of this document was limited. Overall, the conclusions of the White Paper may be overly optimistic, particularly with regard to the locational advantages to high technology firms of access to universities, the Alberta Research Council and the research parks. However, this survey has confirmed the existence of indigeonous high technology development in a number of promising areas other than the oil and gas industry. These ventures may take a long time to develop to commercial success, and while it may be premature to imply the creation of a "Silicon West", if nurtured, there are grounds for optimism about high technology development in this peripheral region of Canada.

Policy Implications

For the Alberta government, fostering high technology development will contribute to the diversification of the provincial economy and improve the region's long-term economic prospects. In any case, it would be short-sighted for the government not to encourage this type of firm and industry, particularly where there is the added incentive of an unduly high reliance on the agricultural base for future revenues and job opportunities after conventional oil and gas reserves are exhausted. However, to support high technology development in Alberta will require flexibility and commitment, not only from the provincial government, but the private sector, the financial community, local government and prominent academic institutions. The role of the provincial government focusses on two fundamental questions :

1. To what extent should the Alberta government attempt to influence or direct private sector high technology activity in general?

2. To what extent should the provincial government specifically finance R&D?

It has been demonstrated that the overall business climate was the most important location factor to high technology firms in Alberta. Thus, a business climate with which entrepreneurs can prosper may provide an environment conductive to innovation. This strategy is less interventionist than using the Heritage Savings Trust Fund to "buy" high technology development or adopting a "picking the winners" strategy, but it is designed to meet the needs of the province's high technology base rather than copying the initiatives and activities of other regions. Buying high technology can be very expensive and it is difficult to measure the total costs and benefits to the province. Attempting to pick the winners can result in targeting the wrong industries for the wrong reasons. It is difficult to push technology into the market place, and therefore the market should be left to sort out the winners and losers. The Alberta Government White Paper supports the idea of creating an environment conducive to entrepreneurship and a strong private sector. The province's strengths and weaknesses were analysed and preliminary policy areas were formulated for discussion. In conjunction with the analysis completed in this thesis, the following policy and program areas, which are designed to encourage indigenous high technology growth, warrant consideration.

Education

High technology firms, particularly those providing business services, depend upon professional and technical manpower. Therefore, emphasis on education is important for establishing and supporting a skilled labour force. Although the White Paper notes that "education should foster ideas of risk taking, innovation and the pursuit of excellence"[5] the following initiatives could contribute to industrial innovation and regional economic development:

i. Reorient appropriate university research toward the need and interests of industry. For example, academic and post-graduate research could combine business and technical education through expanded co-operative education programs. Professors could be encouraged to develop consulting links with the business community.

ii. Establish specifically, co-operative programs for computing business and public administration students in addition to engineering faculty which emphasize university/industry collaboration and will eventually help place graduating students.

iii. Establish flexible part-time programs for adult students in professional and technical occupations to upgrade their skills.

iv. Establish an institute for entrepreneurship where entrepreneurs can upgrade their skills and receive consulting expertise particularly in marketing.

While it is acknowledged that progress is being made in each of these policy areas, greater commitment and organization are vital to strengthening the linkages between universities, government and the private sector.

Scientific Infrastructure

The Alberta government is promoting a scientific infrastructure by establishing research and test facilities, for example, the Alberta Microelectronics Test Centre. Because most high technology firms are used to working with private sector consultants for external R&D support, there is a need to provide an aggressive advertising and awareness program to demonstrate what these facilities can do for business and to gain trust.

Marketing

Most high technology firms identified marketing as a key concern. Because entrepreneurs tend to be technologically oriented, they are more concerned with how the product performs rather than how it can be successfully marketed.[6] Most high technology firms require effective marketing assistance that will teach them how to market their products in addition to knowledge of customs regulations and business practices in foreign countries. Because both the federal and provincial governments offer marketing programs, a review should be carried out to achieve a co-operative effort that minimizes duplication.

Research & Development Tax Credits

Most high technology firms identified R&D tax credits as important to their operations. A failure of the Scientific Research Tax Credit program was that it enabled many companies to raise vast sums of cash which had to be expended before the end of the calendar year. As a result, much money was wasted on projects that did not constitute R&D or meet an identifiable need. To prevent this type of problem from reoccurring, the province should consider an incremental R&D tax credit system based on a working definition of R&D for tax purposes.

Venture Capital

The Government of Alberta has created Vencap Equities Ltd., a publicly trusted venture Capital company. and the Small Business Equity Corporations Program which provides a tax credit or cash rebate for private pools of venture capital, for stimulating venture capital investment. Although Vencap has begun slowly and cautiously, it must be acknowledged that private venture capital firms often review hundreds of potential opportunities, but may only invest in three or four companies a year. However, Vencap in many cases, has been investing in lower risk ventures and is resembling more of a holding company than a venture capital firm. The portfolio should be balanced to include higher risk, but promising high technology ventures.

The S.B.E.C. program is managed by Alberta Tourism and Small Business. While this program has been successful in placing approximately $35 million in risk capital, it is merely regulated by this Department. Applications are analysed and reviewed to ensure conformance with the conditions outlined by the Small Business Equity Corporations Act. The Department does not provide an active information bank to link potential investment firms with companies seeking an equity injection, nor does it provide assistance in preparing business plans or other skills and services which may help strengthen small firms and prospective venture capitalists. The provision of support in these critical areas or assisting firms in locating these services is required without intervening directly in the market or hindering the operation of businesses.

Private Sector Community Participation

Private sector participation is an important and necessary ingredient to the high technology efforts of the provincial government, universities, and local communities. It is clearly lacking in Alberta. Entrepreneurs and executives have a genuine interest in the community in which they have invested and may have expertise in economic development matters. Active participation may also help to establish informal information networks between companies which can stimulate business and investment within a region. In the United States private sector participation has been extensive and visible. Corporate representives have activley established committees and associations for high technology development which work co-operatively with local and state public agencies. In Clark County near Vancouver, Washington, for example, a private sector committee which included representatives form Tektronix Inc. and Hewlett-Packard Ltd., was instrumental in assisting an RCA-Sharp join venture to locate in that municipality.

Local Government Initiatives

The White Paper offers little direction for local governments to link broader development efforts with specific local programs. Similarly, communities like Edmonton and Calgary are only now becoming more aware of the high technology companies in their cities. Comprehensive high technology strategies are required by local governments that emphasize initiative and partnership in the development of programs. This is a long-term commitment.

Agriculture

Although agriculture comprises a major component of the Alberta economy high technology firms associated with this sector were not well represented in this survey sample. Because agriculture represents a renewable resource in addition to an area of significant strength for Alberta, the provincial government should continue to encourage high technology in this sector. In addition, the "Farming for the Future Program" which provides funding for agricultural R&D should assure a more active role to encourage interaction and the exchange of ideas between nominating committees and both prospective and successful applicants. The rigid system presently in place restricts information flow and trust with the business commity.

Foreign Subsidiaries

It has been demonstrated that foreign subsidiaries lack a world product mandate, instead relying on imported technology form the parent firm located outside the country. The provincial government should investigate means for encouraging foreign firms to establish in-house R&D capability and work toward a world product mandate. Successful efforts in these areas would not only stimulate technology development in Alberta but would also create higher paying professional jobs associated with R&D. In the long-term it is possible that high technology spin-offs could emerge as is now being witnessed in similar peripheral regions of the USA such as Colorado.

Employment

At present two out of every three jobs associated with high technology are low paying, non-professional positions. To achieve greater balance in the type of employment being created, preference should be directed at firms which emphasize professional employment associated with R&D a lesser emphasis on manufacturing. With many high technology manufacturing firms transferring their operations to the Far East to take advantage of lower labour costs, a similar series of events could eventually occur in Alberta. The Alberta government has recognized the importance of establishing a "critical mass" of professional and technical workers (for example refer to the Alberta Heritage Foundation for Medical Research p. 94) but lacks specializing training programs or incentives for firms to assist in training professional in employing graduates from Alberta's university and technical colleges. With respect to manufacturing firms, generous provincial and corpoate tax incentives designed to encourage manufacturing in Alberta are already in place.

Research Parks

The Edmonton Research and Development Park is presently in the early stages of development, while the Calgary Research and Development Park remains in the pre-development stage. The provincial government should discourage the development of additional research parks until a significant level of infilling has occurred or it has been demonstrated that existing parks will emerge as successful entities. Only then should the potential for further research park development within metropolitan regions be assessed.

Information

Present industrial data provided by the Alberta Bureau of Statistics are deficient in analysing the development problems of high technology firms in Alberta. S.I.C. Codes and occupational categories have proven to be inadequate and result in double counting. In addition, present information systems often fail to reflect technological developments underway in a region. New methods of data collection must be devised to accommodate high technology development and strengthen the information data base within the province.

The initiatives outlined here are designed to encourage indigenous high technology development. This approach is necessary to build upon the emerging high technology base identified by this thesis research. While many firms will remain small, only one major success story could have a dramatic impact on the Alberta economy. However, if high technology is to gain prominence in Alberta, a long-term commitment, sustained effort and innovative behaviour are required by both the private and public sectors to complement the positive business environment that already exists.

Endnotes: Chapter VIII: Conclusions and Policy Implications

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2. See Alberta Advanced Education Planning Secretariat, Research and Science In Alberta 1982-1983. Alberta Government Publication. July, 1984, pp. 19-22

3. Weiss (in Hall & Markusen) op. cit., pp. 84-86.

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Appendix I

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

Your participation in this study is much appreciated. The important contribution being made by high technology firms to the Alberta economy is well-recognized. However, there is as yet little information available with respect to the structure of the industry and firms and their particular needs in being successful in Alberta. It is with this pragmatic objective that this study will endeavour to provide information which will assist high tech firms in Alberta in their growth and development. Information provided by this study will be used in conjunction with findings of surveys presenting the problems and successes of high tech firms elsewhere in order to make recommendations to aid firms based on the results.

Please be advised that all information provided in your response will be kept strictly confidential and that data will only appear in aggregate form in the analysis of the results so that individual responses will not be identifiable.

Thank you again for your cooperation.

Dr. R.G. Ironside,
Professor and Chairman
Department of Geography,
University of Alberta

QUESTIONNAIRE SURVEY

HIGH TECHNOLOGY DEVELOPMENT IN ALBERTA

Your firm has been asked to participate in this high technology survey. The purpose is to help provide a greater understanding of Alberta's technology base at the firm level in the interests of benefiting the industry.

The survey is divided into four parts:

Part 1: Categorization of high technology firms
Part 2: Performance of high technology firms
Part 3: Location factors
Part 4: Government support programs

Every effort has been made to make the questions clear and concise. However, if you should have any problems in answering questions or have any inquiries about this survey, please feel free to contact:

Mr. Craig Christy 437-4541

or

Dr. R.G. Ironside 432-3274

YOUR CO-OPERATION IS GREATLY APPRECIATED!

This questionnaire was answered by: (please check only one)

Chief Executive Officer ( )
Vice-President ( )
Director ( )
Manager ( )

Other, please specify ____________________

DEFINITIONS

PRIVATE CORPORATION: a chartered company that limits the number of shareholders to less than 50, and restricts shareholders on the right to transfer shares. Members of the public are prohibited to subscribe for securities.

PUBLIC CORPORATION: a chartered company whose shares are listed for trading on a stock exchange or traded over the counter.

RESEARCH AND DEVELOPMENT: creative work undertaken on a systematic basis towards the acquisition and application of new scientific and technical knowledge.

BASIC RESEARCH: original investigations for the advancement of scientific knowledge without specific commercial objectives.

PART-TIME EMPLOYMENT: employees working less than 20 hours per week.

FULL-TIME EMPLOYMENT: employees working a minimum of 35 hours per week.

QUESTIONNAIRE SURVEY

HIGH TECHNOLOGY DEVELOPMENT IN ALBERTA

PART 1. CATEGORIZATION OF HIGH TECHNOLOGY FIRMS

Questions 1-6 deal with the categorization of high technology firms in Alberta. This information is vital for determining the overall base and potential for high technology development in the province.

1. How would you describe the major business activity of your company? Please check only one.

    1. ( ) Experimental and Institutional Farms
    2. ( ) Services Incidental to Agriculture
    3. ( ) Forestry Services
    4. ( ) Mineral Fuels (includes petroleum and natural gas)
    5. ( ) Services Incidental to Mining (includes contract drilling for petroleum)
    6. ( ) Petroleum and Coal Products Industries
    7. ( ) Chemical and Chemical Products Industries (includes pharmaceuticals and medicines)
    8. ( ) Food and Beverage Industries
    9. ( ) Rubber and Plastics Products Industries
    10. ( ) Metal Fabricating Industries (excludes machinery and transportation equipment)
    11. ( ) Machinery Industries
    12. ( ) Transportation Equipment Industries
    13. ( ) Transportation Industries
    14. ( ) Electrical Products Industries
    15. ( ) Communication Industries
    16. ( ) Miscellaneous Manufacturing (includes scientific and professional equipment)
    17. ( ) Services to Business Management (includes engineering and scientific services)

2. Based on percentage of total sales, what is the major product or service produced by this firm?

    a) major product ______________________________

    ____

    b) major service ______________________________

    ____

3. a) How long has your firm been established in Alberta?

<2 years ______ 2-5 years ______ 6-10 years ______ >10 years ______

b) Is your present address a relocation from another centre:

	YES	NO
inside Alberta	( )	( )
outside Alberta	( )	( )

If YES from where? ________________________________

4. a) Is your firm:
a) public corporation ( )
b) private corporation ( )
c) crown corporation ( )
d) other, please specify ____________________

b) Is your firm:
a) an independent Alberta-owned company ( )
b) a Canadian controlled subsidiary ( )
c) a foreign controlled subsidiary ( )

If you answered (a) an independent Alberta-owned company, please ensure that you answer questions 39-43 dealing with entrepreneurship.

c) If a subsidiary firm, where is your head office located?

____

d) If you are an Alberta-owned company, have you established any subsidiary firms?

Yes ______ No ______

e) If yes, please identify where your subsidiary firms are located.

____

5. In 1983, what were your gross revenues?

less than $500,000 ( )
$500,000-$999,000 ( )
$1,000,000-$4.99 million ( )
$5 million-9.99 million ( )
greater than $10 million ( )

6. a) Does your firm carry out a Research and Development (R&D) program?

Yes ______ No ______

b) If yes, is this work carried out in Alberta.

Yes ______ No ______

If you do not carry out an R&D program in Alberta please answer the questions on Technology Transfer only (questions 17-23, p.4-5) and return the questionnaire in the envelope provided.

PART 2. PERFORMANCE OF HIGH TECHNOLOGY FIRMS

Questions 7-43 address the commercial performance of high technology firms. Information concerning growth rates, employment growth, markets, competition, R&D activity, technology transfer and entrepreneurship is necessary for evaluating the strength and viability of high technology firms in this province.

Research and Development (R&D) (see definition page)

7. Is your R&D program: Full-time ( ) Part-time ( )

8. If you are a foreign controlled subsidiary, and do not carry out an R&D program in Alberta, where are your research facilities located?

____

9. Do you prepare a formal R&D budget? Yes ( ) No ( )

10. a) How are your R&D expenditures allocated between:

research _______% development ________%

b) For the research component, what percentage is:

basic ______% applied ________%

c) For the development component, what percentage is:

new product development _______%

improvement/adaptations of existing products ______%

11. Has your investment in R&D increased, decreased, or remained the same?

Increased by _____% Decreased by _____% Remained the same _____

12. Do you expect your investment in R&D to increase, decrease, or remain the same during the next two years?

Increase by _____% Decrease by _____% Remain the same _____

13. Is your R&D program carried out predominantly in-house or externally?

In-house _____ Externally _____

14. Which, if any, of the following groups' facilities do you make use of for external R&D? (Please check more than one if applicable.)

a) ( ) provincial government
b) ( ) universities
c) ( ) Alberta Research Council
d) ( ) National Research Council
e) ( ) Consultants
f) Other, please specify _______________________________________
g) ( ) None of the above

15. What is the main source of your R&D funding?

    a) ( ) retained earnings
    b) ( ) private investors
    c) ( ) provincial government
    d) ( ) federal government
    e) ( ) joint ventures
    f) ( ) other, please specify ____________________

16. What percentage of your R&D funding is financed by government?

    Provincial government ( ) Federal government ( ) Not applicable ( )

Technology Transfer

17. Have you purchased/adopted new technology from external sources in the development of new product(s) or process applications?

    Yes ( ) No ( )

    If you answered YES please proceed to Question 20.
    If NO please answer the following question then proceed to question 24.

18. What factor(s) are preventing your firm from purchasing/adopting new technology?

    a) ( ) financial costs
    b) ( ) lack of information
    c) ( ) uncertain about need
    d) ( ) unaware of technological advances
    e) ( ) lack of skilled labour in Alberta
    f) other, please specify ____________________

19. How did you acquire new technology?

    a) ( ) by equipment purchase
    b) ( ) by licence purchase
    c) ( ) by patent purchase
    d) ( ) by joint venture
    e) other, please specify ____________________

20. What was the source of the new technology?

    a) ( ) parent firm
    b) ( ) other Canadian firms
    c) ( ) foreign-owned Canadian subsidiaries
    d) ( ) foreign firms
    e) ( ) federal government agencies
    f) ( ) provincial government agencies
    g) ( ) University
    g) other, please specify ____________________

21. Where did you first learn of this new technology?

a) ( ) trade shows
b) ( ) journals
c) ( ) federal government: contacts/publications
d) ( ) provincial government: contacts/publications
e) ( ) media
f) ( ) sales contacts
g) other, please specify ____________________

22. If this new technology was purchased/adopted from international sources, was similar technology available from Canadian sources?

Yes ( ) No ( ) Don't know ( )

23. If yes, what were the reasons for not purchasing/adopting technology from Canadian sources?

a) ( ) financial costs
b) ( ) inferior quality
c) ( ) lack of information at time of purchase
d) ( ) lack of availability and servicing in Alberta
e) other, please specify ____________________

Export Markets and Competition

24. Does your firm have internal marketing personnel? Yes ( ) No ( )

25. What percentage of your present sales is in the following markets?

	Product	Service
United States of America	________ %	________ %
Foreign (excluding U.S.A.)	________ %	________ %
Canada (east of Manitoba)	________ %	________ %
Western Canada (4 western provinces)	________ %	________ %
Alberta	________ %	________ %

26. What percentage of your sales in 1980 were in the following markets?

	Product	Service
United States of America	________ %	________ %
Foreign (excluding U.S.A.)	________ %	________ %
Canada (east of Manitoba)	________ %	________ %
Western Canada (4 western provinces)	________ %	________ %
Alberta	________ %	________ %

27. a) Are you actively seeking to diversify your export opportunities?

Yes ( )   No ( )

b) If YES, where?
a) United States .... ( )
b) Japan .... ( )
c) Europe .... ( )
d) Pacific Rim .... ( )
e) Other provinces in Canada ( )
f) other, please specify ____________________

c) Are you receiving financial assistance from the provincial and/or federal governments for identifying export market opportunities?

	Yes	No
provincial government	( )	( )
federal government	( )	( )

28. What firms constitute your major competition? (Please check more than one if applicable.)

a) ( ) U.S. firms
b) ( ) Japanese firms
c) ( ) European firms
d) ( ) Independent Alberta-owned firms
e) ( ) Canadian subsidiaries
f) ( ) Foreign subsidiaries
g) ( ) don't know

29. How many competitors do you have? ____________ Don't know __________

30. Is this competition becoming:
more intense .... ( )
less intense .... ( )
remaining about the same ( )

31. a) What percentage of goods and services by value are purchased from firms located:

in Alberta ________%   outside Alberta ________%

b) If available, would you prefer to buy more from firms in Alberta?

Yes ~~( ) No (~~)

c) What percentage of goods and services by value are sold to firms located:

in Alberta ________%   outside Alberta ________%

Growth Rates

32. Have your gross revenues over the five years previous to 1983 been:

Increasing ( ) Decreasing ( ) Remaining the same ( )

33. Has your net after tax profit over the five years previous to 1983 been:

Increasing ( ) Decreasing ( ) Remaining the same ( ) Experiencing losses ( )

34. By what percentage do you expect your gross revenues to grow over the next two years?

0 - 5% ( )
6 - 10% ( )
11 - 19% ( )
>20% ( )

no change ( )
decline ( )

35. By what percentage do you expect your net after tax profit to grow over the next two years?

0 - 5% ( )
6 - 10% ( )
11 - 19% ( )
>20% ( )

no change ( )
decline ( )

Employment Growth

36. a) How many persons are employed by this firm in Alberta? Note: If your firm is a subsidiary, answer (ii) only. (See definitions at the front of this questionnaire re: full-time and part-time employees.)

	(i) Parent Firm	(ii) Subsidiaries
Full-time	________	________
Part-time	________	________

b) Of these, how many are:

	Full-time	Part-time
a) scientists	________	________
b) engineers	________	________
c) managers	________	________
d) technicians/technologists	________	________
e) salesmen	________	________
f) clerical	________	________

g) Other, please specify ________________________________

c) What percentage of your total staff (full-time and part-time) are engaged in R&D activities? ________%

d) What percentage of your total employees are unionized? ________%

e) What was your payroll at December 31, 1983? $____________

37. a) How many new positions has your firm created:

	Full-time	Part-time
Between 1980-1984	( )	( )
Have not created any new positions	( )	( )
Have reduced staff since 1980	( )	( )

(Please note new positions does not include new employees replacing out-going employees.)

b) Of these new positions created, how many are:

	Full-time	Part-time
a) scientists	( )	( )
b) engineers	( )	( )
c) managers	( )	( )
d) technicians/technologists	( )	( )
e) salesman	( )	( )
f) clerical	( )	( )
g) other..............................	( )	( )

c) What is your employment objective by 1990? (Full-time employees only.)

Total employment 1990 ____________

38. a) Have you found it difficult to attract and retain professional and technical personnel?

Yes ( ) No ( )

b) If yes, what are the reasons? ________________________________

____

____

____

Entrepreneurship

If you are an independent Alberta-owned firm, please complete questions 39 to 43. If NOT proceed to question 44.

39. How many entrepreneurs founded this firm when it was registered? ____________

40. Please identify the professional experience of the entrepreneurs presently with the firm.

Entrepreneur 1 ____

Entrepreneur 2 ____

Entrepreneur 3 ____________________

Entrepreneur 4 ____________________

Entrepreneur 5 ____________________

41. a) What is the level of academic training of each entrepreneur? Please check appropriate box.

ENTREPRENEUR	1	2	3	4	5
Bachelor's degree					
Master's degree					
Ph.D. degree					
Technical Diploma					
Community College Diploma					
Some post-secondary academic training					
No post-secondary academic training					

b) Where did you receive your most important academic training? Please identify the name of the academic institution.

Entrepreneur 1 ____________________

Entrepreneur 2 ____________________

Entrepreneur 3 ____________________

Entrepreneur 4 ____________________

Entrepreneur 5 ____________________

42. How did you initially raise funds for your firm?

a) ( ) personal savings
b) ( ) bank or trust company loan
c) ( ) private investors
d) ( ) public stock underwriting
e) ( ) venture capital company
f) ( ) other, please specify ____________________

43. a) In preparing your business plan, did you receive external management assistance?

Yes ( ) No ( )

Did not prepare a business plan ( )

b) Please identify those management areas in which you required assistance:

PART 3. LOCATION FACTORS

Questions 44-50 deal with locational behaviour of high technology firms in Alberta. This information will provide a greater understanding of the needs of high technology firms, which has significant implications for economic development.

44. To what extent have each of the following factors influenced your location in Alberta? (Circle 1-Very Important; 2-Important; 3-Neutral; 4-Slightly Important;5-Not Important.) Please provide an answer for each of the factors listed below.

FACTOR	VERY IMPORTANT	IMPORTANT	NEUTRAL	SLIGHTLY IMPORTANT	NOT IMPORTANT
Founding entrepreneur lived there	1	2	3	4	5
Labour skills/availability	1	2	3	4	5
Labour costs	1	2	3	4	5
Proximity to university	1	2	3	4	5
Provincial tax climate	1	2	3	4	5
Access to raw materials	1	2	3	4	5
Energy costs/availability	1	2	3	4	5
Access to markets	1	2	3	4	5
Cost of living	1	2	3	4	5
Local transportation	1	2	3	4	5
Proximity to international airport	1	2	3	4	5
Proximity to domestic airport	1	2	3	4	5
Recreational opportunities	1	2	3	4	5
Cultural amenities	1	2	3	4	5
Climate	1	2	3	4	5
Provincial government support programs	1	2	3	4	5
Availability of venture capital	1	2	3	4	5
Overall business climate	1	2	3	4	5
Local government's incentives to industry	1	2	3	4	5
Proximity to government dept's/agencies	1	2	3	4	5
Political stability	1	2	3	4	5

45. Which of the following factors are important to your firm's continuing operations at its present location? (Circle 1-Very Important; 2-Important; 3-Neutral; 4-Slightly Important; 5-Not Important.) Please provide an answer for each of the factors listed below.

FACTOR	VERY IMPORTANT	IMPORTANT	NEUTRAL	SLIGHTLY IMPORTANT	NOT IMPORTANT
Financial Services	1	2	3	4	5
Advertising Services	1	2	3	4	5
Office Overload Services	1	2	3	4	5
Legal Services	1	2	3	4	5
Insurance Services	1	2	3	4	5
Engineering Services	1	2	3	4	5
Office & Lab Equip. Rental/Leasing Services	1	2	3	4	5
Management Consulting & Public Relations Services	1	2	3	4	5
Commercial Testing Centres	1	2	3	4	5
Government's Research & Development Labs	1	2	3	4	5
Private Research & Development Labs	1	2	3	4	5
Computer Programming & Data Processing Services	1	2	3	4	5
Research and Development Parks	1	2	3	4	5
Innovation Centres	1	2	3	4	5
Information Banks	1	2	3	4	5
Transportation Services	1	2	3	4	5

46. Would locating in an established research park benefit your firm by:

	Yes	No	Don't know
a) improving sales/profits	( )	( )	( )
b) raising your company profile	( )	( )	( )
c) improving communications with government agencies and other firms	( )	( )	( )
d) providing a more attractive working atmosphere	( )	( )	( )
e) providing greater access to university research facilities	( )	( )	( )
f) increasing the availability of ancillary services	( )	( )	( )
g) providing an information environment to stimulate ideas	( )	( )	( )

47. If you are not at present in a research park, what factors are preventing your firm from relocating to one?

48. Could you successfully operate your firm out of any other city or town in Alberta?

Yes ( ) No ( ) Don't know ( )

49. How would you rate Alberta's towns and cities in terms of satisfying your firm's locational requirements? (Circle 1-Very Satisfactory; 2-Satisfactory; 3-Acceptable; 4-Unsatisfactory, 5-Very Unsatisfactory.) Please provide an answer for each of the urban centres listed below.

	VERY SATISFACTORY	SATISFACTORY	NEUTRAL	UNSATISFACTORY	VERY UNSATISFACTORY
Edmonton	1	2	3	4	5
Calgary	1	2	3	4	5
Lethbridge	1	2	3	4	5
Red Deer	1	2	3	4	5
Lloydminster	1	2	3	4	5
Medicine Hat	1	2	3	4	5
St. Albert	1	2	3	4	5
Spruce Grove	1	2	3	4	5
Stony Plain	1	2	3	4	5

	VERY SATISFACTORY	SATISFACTORY	NEUTRAL	UNSATIS-FACTORY	VERY UNSATISFACTORY
Fort Saskatchewan	1	2	3	4	5
Leduc	1	2	3	4	5
Wetaskiwin	1	2	3	4	5
Hinton	1	2	3	4	5
Edson	1	2	3	4	5
Camrose	1	2	3	4	5
Drumheller	1	2	3	4	5
Airdrie	1	2	3	4	5
Brooks	1	2	3	4	5
Crowsnest Pass	1	2	3	[illegible]	5
Ft. McMurray	1	2	3	4	5
Grande Prairie	1	2	3	4	5
Peace River	1	2	3	4	5

PART 4. GOVERNMENT SUPPORT PROGRAMS

Questions 50-54 address government support programs. The purpose is to determine the importance and effectiveness of existing high technology programs to firms in Alberta, as well as allow you the opportunity to identify what types of program initiatives you feel all levels of government should be pursuing.

50. a) How important are federal government subsidies (financial grants and tax incentives) to your R&D program?

	VERY IMPORTANT	IMPORTANT	NEUTRAL	SLIGHTLY IMPORTANT	NOT IMPORTANT
Financial Grants	1	2	3	4	5
Tax Incentives	1	2	3	4	5

b) How important are provincial government subsidies (financial grants and tax incentives)?

	VERY IMPORTANT	IMPORTANT	NEUTRAL	SLIGHTLY IMPORTANT	NOT IMPORTANT
Financial Grants	1	2	3	4	5
Tax Incentives	1	2	3	4	5

51. Are there other measures which you feel would be helpful to your business?

____

____

52. a) Do you make use of any Alberta government support programs?

Yes ( ) No ( )

b) If YES, Please identify ______________________________

____

53. a) Have you reviewed the provincial government White Paper "Proposals for an Industrial and Science Strategy for Albertans 1985-1990?"

Yes ( ) No ( )

b) If yes, do you feel this proposed strategy will contribute to the growth of high technology firms in general?

Yes ( ) No ( ) Don't know ( )

c) Do you feel any of the policy measures outlined in the White Paper will directly or indirectly assist your firm?

Yes ( ) No ( )

54. Which do you feel is the most appropriate level of government to give support to your firm?

( ) Municipal
( ) Provincial
( ) Federal
( ) No level of government

COMMENTS